

U.S. Mines Bureau
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

JOSEPH A. HOLMES, DIRECTOR

COALS

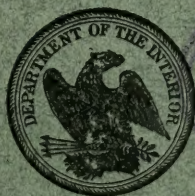
AVAILABLE FOR THE MANUFACTURE OF
ILLUMINATING GAS

BY

A. H. WHITE AND PERRY BARKER

COMPILED AND REVISED BY

HERBERT M. WILSON



WASHINGTON
GOVERNMENT PRINTING OFFICE
1911

Bulletin 6

DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

JOSEPH A. HOLMES, DIRECTOR

COALS
AVAILABLE FOR THE MANUFACTURE OF
ILLUMINATING GAS

BY

A. H. WHITE AND PERRY BARKER

COMPILED AND REVISED BY

HERBERT M. WILSON



WASHINGTON
GOVERNMENT PRINTING OFFICE

1911



Digitized by the Internet Archive
in 2011 with funding from
University of Toronto

CONTENTS.

	Page.
Introduction.....	7
General statement.....	7
Personnel.....	8
Acknowledgments.....	9
Description of tests.....	9
Coals tested.....	9
Summary of results.....	9
Yield of coke.....	10
Value of a testing station.....	11
Equipment of plant.....	11
General statement.....	11
Regulation of pressure in retort.....	13
Gas-sampling devices.....	14
Laboratory apparatus.....	15
Procedure of tests.....	15
Methods of sampling and analysis.....	17
Ammonia.....	17
Sampling and analysis of tar and gas for naphthalene.....	18
Collection of samples.....	18
Analysis.....	19
Apparatus.....	20
Remarks.....	20
Hydrogen sulphide in purified gas.....	21
Yield of coke.....	21
Yield and quality of gas.....	22
Collection of samples.....	22
Candlepower.....	22
Analysis.....	22
Measurement of retort temperatures and pressures.....	23
Weight balance.....	23
Basis of computations.....	23
Coincidence of observations.....	23
Presentation of results.....	24
Verification of data.....	24
General statement.....	24
Ammonia.....	26
Naphthalene.....	26
Quantity and quality of gas.....	26
Coal and coke.....	27

	Page.
Details of tests.....	28
Coal A. A. 1, from Pittsburg bed, Scott Haven, Pa.....	28
Coal A. A. 8, from Blocton, Ala.....	31
Coal A. A. 4, from Oak Creek, Colo.....	32
Coal A. A. 6, from Sopris, Colo.....	33
Coal A. A. 12, from Harrisburg, Ill.....	34
Coal A. A. 3, from Hellier, Ky.....	35
Coal A. A. 9, from Saginaw, Mich.....	36
Coal A. A. 2, from Van Houten, N. Mex.....	37
Coal A. A. 10, from La Follette, Tenn.....	38
Coal A. A. 5, from Kanawha No. 2 bed, Page, W. Va.....	39
Coal A. A. 7, from Hanna, Wyo.....	40
Tabulated results.....	41
Manner of recording and computing data.....	51
General statement.....	51
Sheets for recording tests.....	51
Coal and coke.....	51
Retort temperature.....	52
General temperature.....	52
Pressures.....	53
Calorimeter.....	54
Photometer.....	54
Gas analysis.....	55
Tar.....	56
Ammonia.....	57
Tar tubes.....	58
Naphthalene in tars.....	58
Naphthalene in gas.....	58
Computations for illuminating-gas tests.....	59
Coal and coke.....	59
Retort temperature.....	59
Pressures—gas-made.....	59
General temperatures.....	60
Calorimeter.....	60
Photometer.....	60
Gas analysis.....	60
Tar and liquor.....	61
Ammonia.....	61
Naphthalene.....	62
Sulphur.....	62
Specimen computation sheets.....	62
Coal.....	62
Coke.....	62
Gas yield by half-hour intervals.....	63
Average heat value of gas.....	63
Candlepower of gas.....	63
Gas analyses.....	64
Calculation of cubic feet of gas for periods shown on sheet A 10, taken from meter readings of 5-minute intervals.....	64
Calculation of tar suspended in gas at outlet of separator for half-hour periods, from weights of tar per period as sampled.....	65
Ammonia.....	65
Weight of naphthalene.....	66
Naphthalene data.....	66

	Page.
Manner of recording and computing data—Continued.	
Sheets for recording computed data.....	67
Retort data.....	67
Gas made.....	68
Gas analyses.....	69
Weight of liquor and tar.....	70
Tar at inlet and outlet of separator.....	72
Elimination of tar by separator.....	72
Ammonia.....	73
Naphthalene at outlet of separator.....	74
Total weight of naphthalene.....	75
Naphthalene and sulphur.....	75
Publications on fuel testing.....	76

TABLES.

	Page.
TABLE 1. Source of coals tested at Ann Arbor, Mich.....	9
2. Weight per cubic foot of various gases saturated with moisture, at 60° F. and 30 inches barometric pressure.....	26
3. Comparative analyses of coal and coke.....	41
4. Analyses and composition of coals.....	44
5. Retort operation, coal and coke.....	45
6. Yield, heating value, and candlepower of gas.....	46
7. Yield of tar, ammonia, sulphur, and naphthalene.....	46
8. Results of tests on eleven coals from various States.....	47

ILLUSTRATIONS.

	Page.
PLATE I. Condensers, tar separator, engine, exhauster, and tar washer; with aspirator tanks and apparatus for sampling ammonia and naphtha- lene in position.....	12
II. A, Detail of exhauster, showing by-pass and diaphragm pressure regulator; B, station meter, proportional meter, and gas tanks 1 and 2.....	14
III. Ammonia scrubber and two of the gas tanks, with apparatus for determining hydrogen sulphide in position.....	16
IV. Progress of coal distillation by half-hour periods.....	24
FIGURE 1. Diagrammatic elevation of illuminating-gas experiment station....	10
2. Floor plan of illuminating-gas experiment station.....	11
3. Sectional elevation of tar separator.....	12
4. Tar and ammonia washer.....	13
5. Purifying box.....	14
6. Apparatus for analysis of tar.....	19
7. Retort temperatures, 5-minute periods, test 35. (Sheet C 2).....	67
8. Yield of gas, 5-minute periods, test 35. (Sheet C 2).....	68
9. Yield and quality of gas, half-hour periods, test 35. (Sheet C 4)...	69
10. Composition of gas, half-hour periods, test 35. (Sheet C 6).....	70
11. Yield of liquor and tar, half-hour periods, test 35. (Sheet C 8)....	71
12. Yield of ammonia, half-hour periods, test 35. (Sheet C 10).....	72

COALS AVAILABLE FOR THE MANUFACTURE OF ILLUMINATING GAS.

By A. H. WHITE and PERRY BARKER.

INTRODUCTION.

By HERBERT M. WILSON.

GENERAL STATEMENT.

In a consideration of the various means whereby more economical and more efficient use may be made of the fuels in the United States, the possibility of obtaining for the production of illuminating gas other and cheaper fuels than the Pennsylvania coals demands attention. For the Government, as well as for private corporations and the householder, there can be no more economical and efficient way of using some coals than through the medium of illuminating gas. In the stove, gas reduces the labor cost of heat production and lessens the drudgery of the kitchen; burned in the Welsbach mantle, it is an excellent and cheap illuminant. In addition, the coke that remains after the gas has been recovered furnishes a smokeless fuel that has about the same heating value as anthracite. Hence any investigations that will indicate how local coals through proper treatment may be substituted for the higher priced and rapidly vanishing Pennsylvania gas coals will bring about lower prices for both gas and coke and will also aid to conserve for use in metallurgical processes the coking coals of Pennsylvania and of other States.

The annual drain on the gas-coal resources of this country and the importance of the gas and coke industries are indicated by the fact that 8,390,129 tons of coal were carbonized in retorts in the United States in 1909. The resulting salable products from by-product ovens were 15,791,220,000 cubic feet of coal gas, 6,254,644 tons of coke, and 60,126,000 gallons of tar. The total value of all by-products was about \$28,508,637.

There are few well-developed coal fields in this country that furnish coal satisfying all the requirements of illuminating-gas manu-

facture. Most of the coal used hitherto has come from western Pennsylvania, the quantity supplied by other fields being relatively small. The introduction of gas coals from new or little-known districts, because of the lack of necessary testing stations and of scientific study of the complex process of gas manufacture, has been difficult.

The Michigan Gas Association took a step in the right direction when, in continuation of its cooperative research work with the department of chemical engineering of the University of Michigan, it erected in 1906, at Ann Arbor, Mich., a complete experiment station for the study of illuminating-gas manufacture. Much patient experimenting was done in designing this plant, and many changes were made in its operation before results were procured which were intelligible and could be compared with those obtained at gas works. The experiment station, as it now stands, represents the best thought of many gas engineers who freely gave their time to perfecting it.

When the technologic branch of the United States Geological Survey took up illuminating-gas investigations, it found that the pioneer work done at this plant was of much importance. Accordingly, an arrangement was made with the University of Michigan whereby Alfred H. White, professor of chemical engineering, who had directed the work at the plant, assumed charge of the Survey's investigations. For convenience and economy the work was carried on at Ann Arbor, Mich., with the consent of the Michigan Gas Association and the Ann Arbor Gas Co.; the latter had provided much of the original installation and furnished certain facilities whereby the tests were made on a commercial basis.

The investigations were so directed as to permit the testing of coals from different parts of the United States. The results show that certain coals from which good yields of gas had been expected can not be considered as available for illuminating-gas manufacture, whereas other coals give promise and should be investigated further.

The data contained in this report are the outcome of the cooperative work at the laboratory mentioned during parts of the years 1908 and 1909. The report is published as a bulletin of the Bureau of Mines, because the act of Congress which established that bureau provided for the transfer to it of the fuel testing that was being carried on by the United States Geological Survey.

PERSONNEL.

The investigations were under the supervision of Professor White. Perry Barker, assistant engineer of the United States Geological Survey, was assigned as principal assistant. After the resignation of Mr. Barker his work was continued by Dwight F. Smith, junior engineer. In addition, John H. Wyman and William A. Dunkley

rendered efficient service upon the tests. The mine sampling was in charge of George S. Pope, who, with K. M. Way and P. M. Riefkin, all of the United States Geological Survey, collected and shipped the coals tested.

ACKNOWLEDGMENTS.

Acknowledgment is made of advice from various members of the Michigan Gas Association in regard to the working details of the experiment station, and of helpful assistance from the officers and engineers of the Detroit City Gas Co., who willingly devoted time to the operation of the plant during the course of these tests.

DESCRIPTION OF TESTS.

COALS TESTED.

All samples taken for test were loaded under the inspection of an official of the United States Geological Survey, who also examined the mine and took mine samples for analysis. This procedure enabled those in charge of the tests to obtain samples with authentic histories and to make the scope of the inquiry much broader than that of the earlier investigations at the Ann Arbor plant.

Seventeen tests of coal from 11 localities were made, and the results are incorporated in this report. Table 1 summarizes the data relative to the samples collected.

TABLE 1.—*Source of coals tested at Ann Arbor, Mich.*

Field No.	Test No.	Bed.	Locality.	Railroad.
A. A. 1.....	18, 19, 20, 32.	Pittsburg.....	Scott Haven, Allegheny County, Pa..	Pittsburg & Lake Erie.
A. A. 2.....	28, 22.....	Raton.....	Van Houten, Colfax County, N. Mex..	Santa Fe.
A. A. 3.....	30, 21.....	Upper Elkhorn.....	Hellier, Pike County, Ky.....	Chesapeake & Ohio.
A. A. 4.....	24.....	Yampa.....	Oak Creek, Routt County, Colo.....	Denver, North-western & Pacific.
A. A. 5.....	25, 27.....	Kanawha, No. 2..	Page, Fayette County, W. Va.....	Virginian.
A. A. 6.....	26.....	Sopris.....	Sopris, Las Animas County, Colo.....	Colorado & Southern.
A. A. 7.....	29.....	No. 2 or lower.....	Hanna, Carbon County, Wyo.....	Union Pacific.
A. A. 8.....	33.....	Thompson.....	Blocton, Bibb County, Ala.....	Mobile & Ohio.
A. A. 9.....	34.....	Saginaw.....	Saginaw, Saginaw County, Mich.....	Michigan Central.
A. A. 10.....	31.....	Rex.....	La Follette, Campbell County, Tenn.....	Louisville & Nashville.
A. A. 11.....	35.....	No. 5.....	Harrisburg, Saline County, Ill.....	Big Four.

SUMMARY OF RESULTS.

The material here presented constitutes a progress report of results obtained in testing different coals to determine their value for use in gas works. The results are to be taken as tentative and suggestive, and not in any way as final. Indeed, since a coal that would give good results in one gas works might not prove satisfactory under the differing conditions prevailing at another, a testing station should

hardly be expected to make positive statements as to the value of a given coal. The purpose of such a station should rather be to test the coal under diverse conditions and to find what conditions give the best returns. The work here set forth falls short of that ideal chiefly because of the scantiness of the data. Gas coals should be tested in the retort at both high and low temperatures, and the tests should be repeated until it is fairly certain that no serious error has been made; but since a long time is required for a complete study of a number of coals, it has seemed wise to present the data collected on these 11 coals with only a slight interpretative discussion and to leave the reader to draw such conclusions as seem warranted.

YIELD OF COKE.

Although the results given in this report have been studied from various standpoints and have suggested some interesting deductions, the only conclusion which seems to apply to all coals well enough to warrant presentation is that relating to the percentage yield of coke. This percentage is only slightly dependent on retort temperature, for the retort is always hot enough to drive off the volatile matter in a coal, and the secondary changes of the distillation products at high retort temperatures do not greatly affect the yield of coke.

As is to be expected, the yield of coke is roughly proportionate to the ratio of the total fixed carbon to the volatile matter of the coal. From calculations based on the ratio:

$$\frac{\text{Fixed carbon} + \text{ash}}{\text{Moisture} + \text{volatile matter}}$$

the rank shown in the table below is obtained. The agreement shown between the computed ratio and the actual percentage of coke is close, the only coal not in agreement being the one from New Mexico.^a

Coke yield of coals tested.

Rank of coal.	Fixed carbon+ash Moisture+ volatile matter	Percentage of coke from coal as charged.
1. Wyoming.....	0.82	50.2
2. Michigan.....	1.43	59.5
3. Oak Creek, Colo.....	1.53	60.0
4. Illinois.....	1.55	62.3
5. Tennessee.....	1.58	66.8
6. Pennsylvania.....	1.82	67.0
7. Kentucky.....	1.88	67.0
8. New Mexico.....	1.93	68.9
9. Alabama.....	2.04	68.3
10. West Virginia.....	2.21	73.3
11. Sopris, Colo.....	2.90	74.9

^a Errors in one of the two tests, 22 and 28, made with this coal are probably responsible for the coal not being in agreement. The weight of coal charged in test 28 may have been wrongly reported. See page 36.

VALUE OF A TESTING STATION.

It seems safe to say that the most important contributions thus far of the testing station to illuminating-gas investigations have been its own development and the proof that it can yield reliable results. The cost of equipping a similar plant at a gas works is not high, and valuable returns can be obtained without the large testing crew required by the efforts made in these experiments to collect all possible data. Seemingly, it would be well worth while for individual gas works to install such plants for working out their own peculiar problems.

EQUIPMENT OF PLANT.

GENERAL STATEMENT.

The gas was taken from a single retort of the standard D-shape, 26 inches wide by 16 inches high by 9 feet long, one of the upper retorts (A, figs. 1 and 2) of a bench of six with three-quarter depth regenerative setting. When the plant was in operation the valve C was closed and D was opened, allowing the gas to pass into the con-

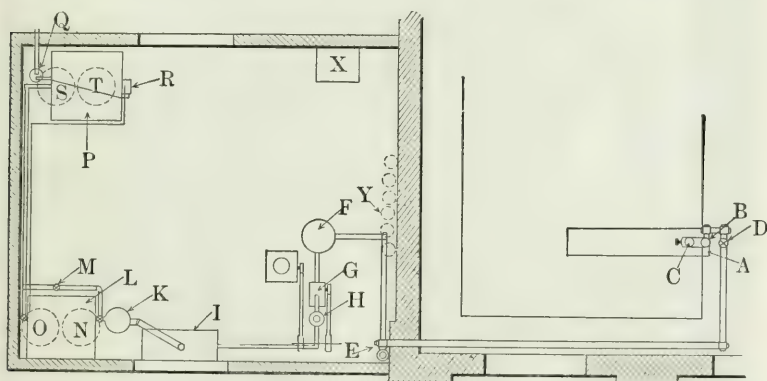
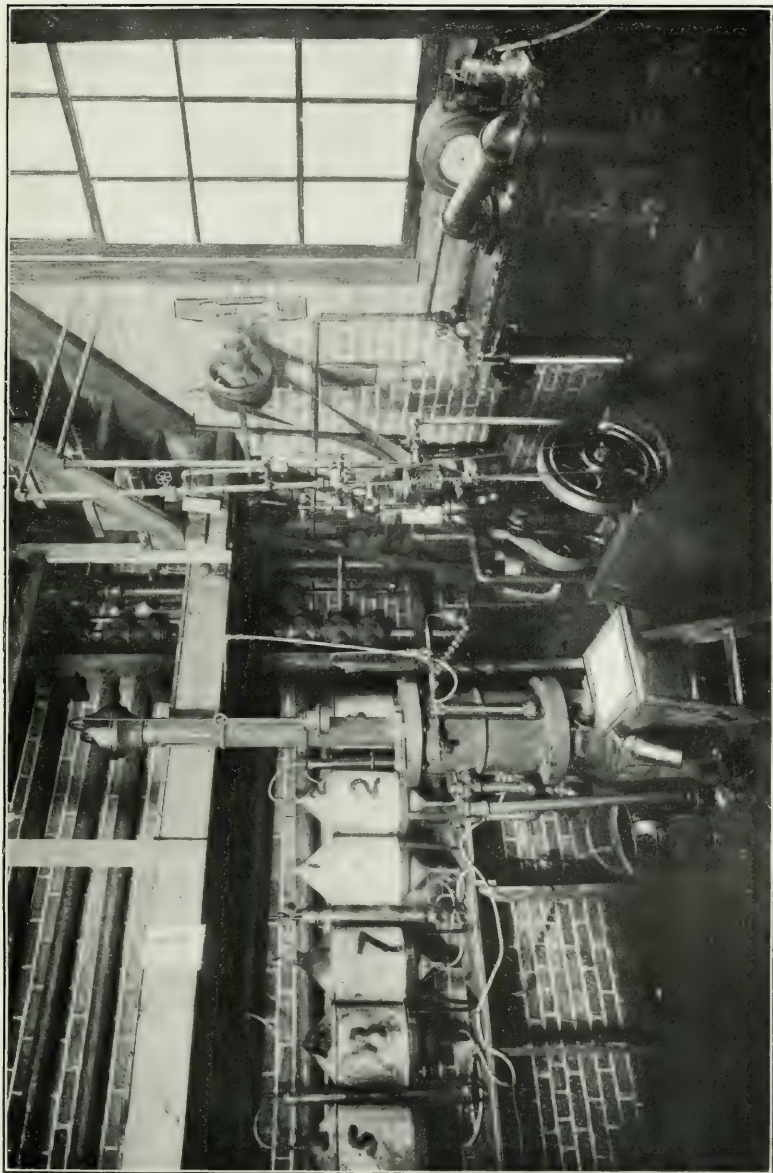


FIGURE 2.—Floor plan of illuminating-gas experiment station.

densing system E. The condensers were so equipped that either water or steam could be passed through the cooling jackets, thereby insuring a fairly accurate control of the gas temperature.

From the condensers the gas was drawn through a tar separator (Pl. I; fig. 3; also F, figs. 1 and 2) of the Pelouzé and Audouin type and constructed especially for this plant, by a blower (Pl. II, A, and G, fig. 1) driven by a 4-horsepower vertical engine. This blower was placed beyond the tar extractor in order to eliminate any error from its possible action as a tar separator. In a by-pass around the exhauster was a pressure regulator, H, so counterpoised that a nearly uniform pressure was maintained at the retort.



CONDENSERS, TAR SEPARATOR, ENGINE, EXHAUSTER, AND TAR WASHER; WITH ASPIRATOR TANKS AND APPARATUS FOR SAMPLING AMMONIA AND NAPHTHALENE IN POSITION.

The condensers (Pl. I) were in three vertical units, and had annular spaces in which either cold or hot water could be circulated so that the gas could be brought to the inlet of the tar separator under fairly well controlled conditions.

REGULATION OF PRESSURE IN RETORT.

As the quantity of gas to be handled was small and varied during the test from a possible maximum of 12 feet per minute to a minimum

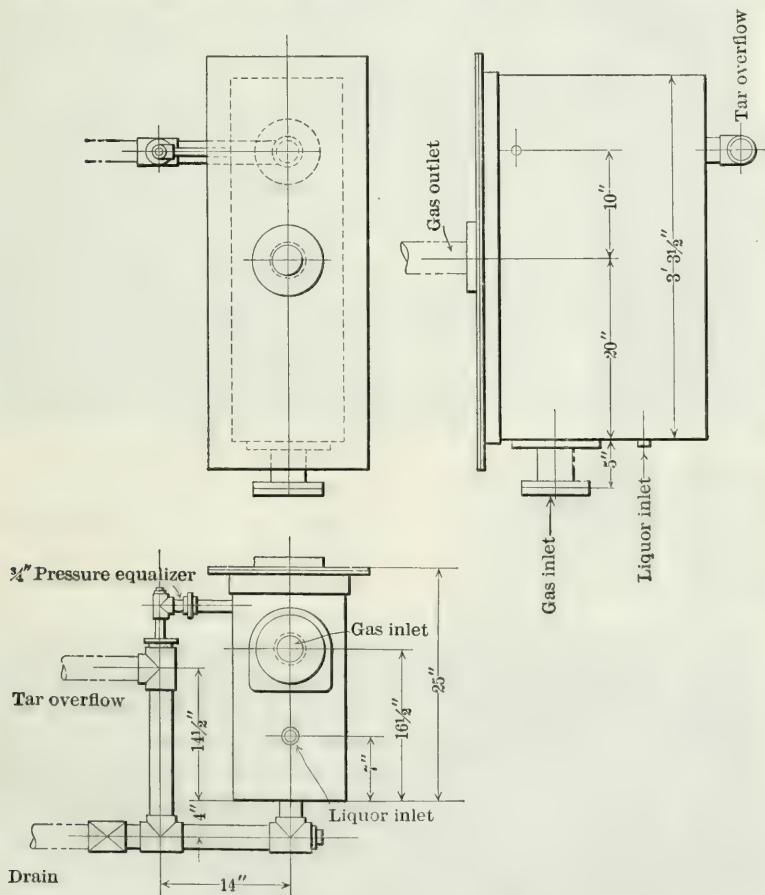


FIGURE 4.—Tar and ammonia washer.

at the end of the run of 1 foot per minute, trouble was experienced in obtaining a satisfactory exhauster. The slow-speed exhauster that was first used transmitted positive and negative nodes of compression which produced rapid fluctuations of pressure, equivalent to 1 inch of water, at the retort. Three different exhausters and several modifications of governors were tried in the effort to overcome this difficulty.

In the final arrangement a small blower, run at about 400 revolutions per minute, had a primary by-pass operated by a hand wheel for rough regulation and a secondary by-pass controlled by a modified diaphragm governor (II, fig. 1), which was actuated through a $\frac{3}{4}$ -inch pipe by the pressure of the gas in the retort. This arrangement was not perfect, for the leather diaphragm soon stiffened by contact with the unpurified gas and did not respond just as quickly as the fluctuating speed of the engine required; but with care it was possible to operate the regulating device so that the retort pressure never for

over a minute at a time varied more than one-tenth of an inch from the one-tenth of an inch back-pressure intended to be kept on the retort.

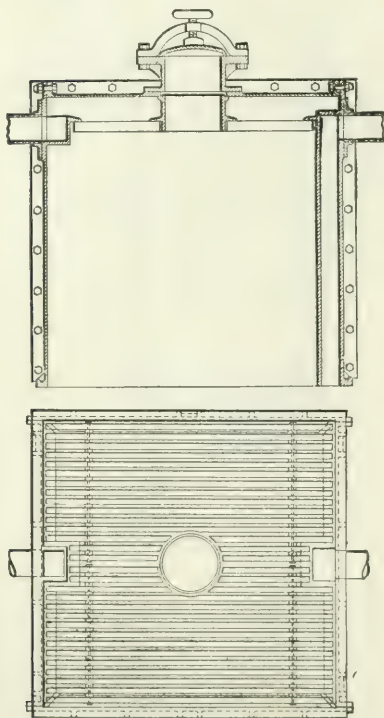


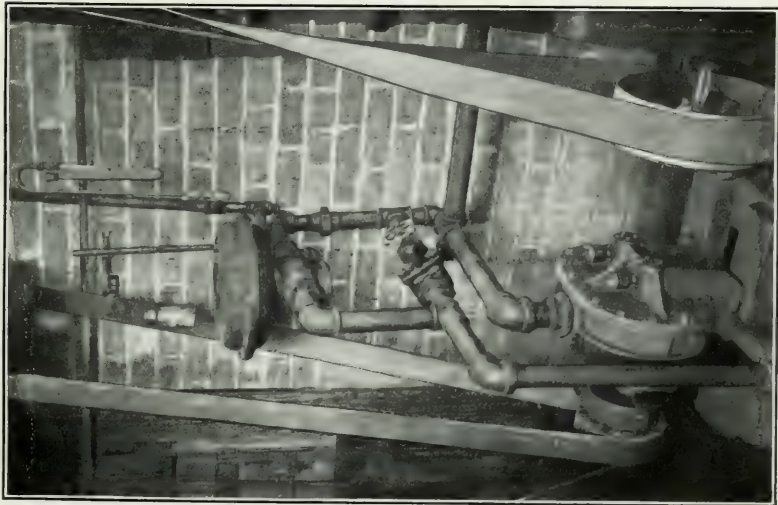
FIGURE 5.—Purifying box.

run. This tank was filled by a small wet meter that worked as a pump and was geared to the shaft of the station meter, as shown in Plate III and at R in figure 1, so that an aliquot part of all the gas made was forced by the meter to the proportional tank. A diaphragm pressure regulator (U, fig. 1) kept a constant pressure on the inlet of this small meter.

So far as appearances went the pump and pressure regulator worked well, but the chemical composition and heating value of the gas collected by the proportional tank did not compare as they should with the corresponding figures for the average of the samples from the half-hour tanks. The proportional tank usually gave high

GAS-SAMPLING DEVICES.

Much attention was paid to improving the accuracy of the various gas-sampling devices. The tanks which sampled the gas by half-hour periods (1 and 2, Pl. I, and S and T, fig. 1) were made, with slight modifications, according to the design published in the proceedings of the American Gas Institute for 1907 (p. 443), and gave relatively little trouble, for there was not much variation in the rate of production nor in the quality of the gas during a single half hour. The reverse was true of the proportional tank (Pls. II, B, and III, and O, fig. 1), which was supposed to collect a mixed sample representing the gas made from beginning to end of the



A. DETAIL OF EXHAUSTER, SHOWING BY-PASS AND
DIAPHRAGM PRESSURE REGULATOR.



B. STATION METER, PROPORTIONAL METER, AND GAS TANKS 1 AND 2.

results, which is the reason for the belief that the proportional meter lagged at the extremely slow speeds at the end of the test and did not deliver the proportional quantity of the poor gas then made. It is possible, also, that incomplete mixing of the heavy, rich gases at the bottom of the proportional tank with the light, poor gases at the top caused part of the trouble.

LABORATORY APPARATUS.

The laboratory equipment included an excellent bar photometer, a Junker calorimeter, a complete gas analysis outfit, a Drehschmidt apparatus for determining the total sulphur in the purified gas, two Hoskins pyrometers and a Morse thermogage for optical measurement of retort temperatures.

Some of the chemical work was done at this laboratory and some at the university laboratory. The analyses of all the coals collected and of all the cokes produced were made at the Pittsburgh laboratory of the United States Geological Survey.

PROCEDURE OF TESTS.

Three tons of coal were shipped as a sample from each mine, usually in canvas sacks holding 100 pounds each. Some of the coal was screened before shipment, but as many of the mines had no screens much of the coal was forwarded in run-of-mine form. Rough handling during shipment broke up some of the coals considerably. To make all tests comparable in respect to size of coal charged into the retort, all coals, except on the first few tests, were screened with a standard screen such as is used at the mines in preparing gas coal. This screen, 2 feet wide and 6 feet long, was made of one-fourth inch bar iron spaced to three-fourths inch and set at an angle of 30°. The fine coal which fell through the screen was rejected, although it was frequently sampled and analyzed to determine the effect of screening on the separation of impurities.

Before starting a regular test on any given coal a preliminary charge of 400 pounds of the coal was carbonized for four and one-half hours to fill all parts of the condensing system with the distillation products and to prove that everything was in order. No test observations were taken in this preliminary run and the condensed tar and liquor were allowed to flow into the tar well of the city gas works. Meanwhile the jars for the collection of tar and liquor were tared and tagged, the gas-sampling tanks and vessels were filled with water, the sampling apparatus for determining ammonia and naphthalene in the gas was put in place, the coal for the test proper was weighed, and the pyrometer for measuring the temperature in the fire space surrounding the retort was put through the hole in the end wall of

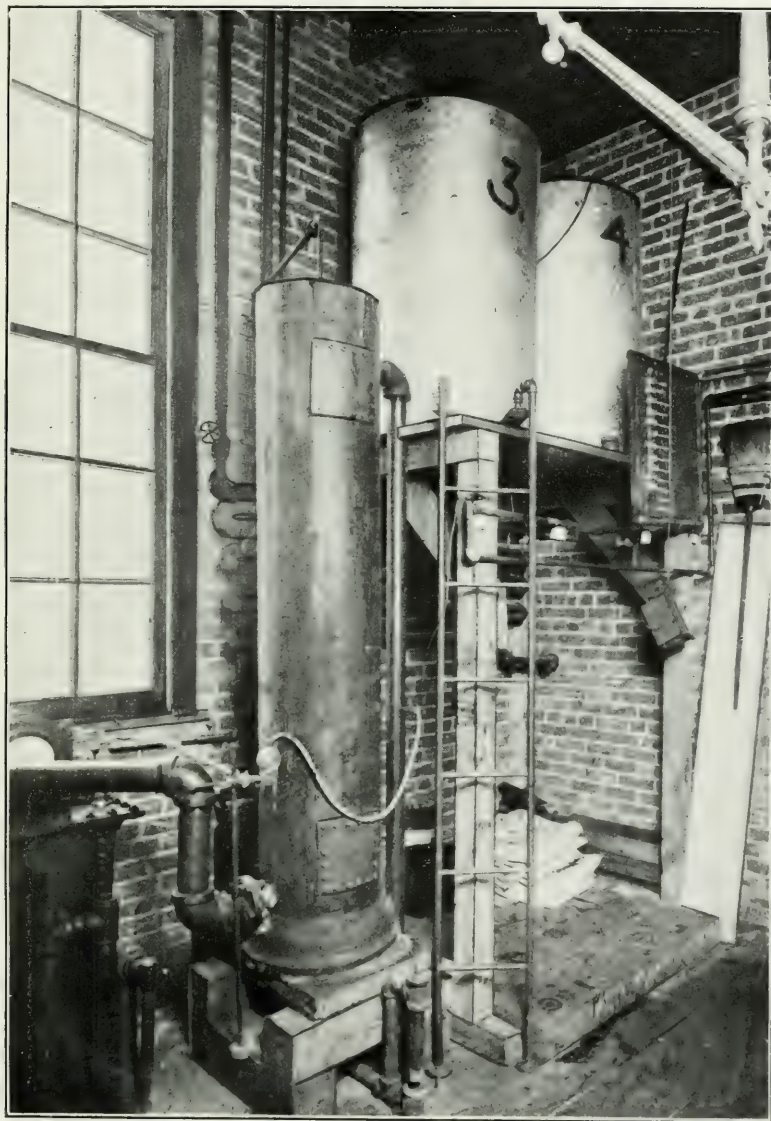
the setting (1, fig. 1) until the thermocouple was about $1\frac{1}{2}$ inches from the middle of the retort.

While the coke of the preliminary test was being drawn, the valve into the tar well was closed, the tar that had accumulated in the Pelouzé & Audouin tar separator was drawn off and the tar separator itself filled to overflowing with fresh ammoniacal liquor from the works; the jars for the collection of tar and liquor were put in place on the condenser (*a* and *c* of fig. 1), and the hands of the station meter were set at zero.

While this was being done in the experimental plant, an operator in the retort house was supervising the charging of the test retort. The retort was first examined to make sure it was clean and in serviceable condition; then the car, which contained the exact weight of coal to be used, was brought up and the coal was charged by the regular stokers in the usual manner. As soon as the mouthpiece was closed the rise in pressure shown by the gage in the experimental plant notified the operator there, who at once started the engine. The pyrometer to measure the temperature on the inside of the retort (2, fig. 1) was put through the hole in the mouthpiece and pushed back until the unprotected thermocouple rested on the coal halfway from the front to the back of the retort. The pyrometer was then luted in. After the operator had made sure that the mouthpiece and all connections were tight, he returned to his station.

In the experimental plant the speed of the engine was so regulated that the manometers indicating the pressure on the mouthpiece of the retort and at the inlet of the tar separator (*d*, *h*, fig. 1) showed a back pressure of about one-tenth of an inch of water. So long as the manometers gave concordant readings, there was free communication between them. After the pressure had been regulated by the engine throttle and the gate valve on the by-pass of the exhauster, the diaphragm regulator controlled it automatically. As the yield of gas dropped off near the end of the run, it was necessary to open the gate valve on the by-pass more and more, thereby allowing the gas to circulate more freely through the by-pass and diminishing the suction on the retort.

The collection of tar and ammonia liquor in jars (*a*, *c*, fig. 1) and the registration of the gas started automatically as soon as the retort was closed. The apparatus for testing the ammonia in the gas at the inlet of the tar separator (Pl. I and *b*, fig. 1) and the naphthalene in the gas at the outlet (fig. 1, *f*) were also started promptly at the beginning of the test, as was the H_2S sampling apparatus. However, since the system had filled with air while the coke of the preliminary charge was being drawn, a five-minute interval was allowed to elapse before the gas for candlepower and heat-value tests was turned into the sampling tank S or T.



AMMONIA SCRUBBER AND TWO OF THE GAS TANKS, WITH APPARATUS FOR DETERMINING HYDROGEN SULPHIDE IN POSITION.

The division of duties among the testing crew was as follows: One man read the station meter every five minutes, and also recorded the pressures shown by the gage (II, fig. 1) on the diaphragm governor line from the standpipe, the pressure at the inlet of the tar separator F, the differential pressures on the separator *e*, and tar washer I, and the pressure at the meter outlet *k*. A second man at five-minute intervals read temperatures at the inlets of the three units of the condensing system 4, 5, and 6, at the inlet and outlet of the tar separator 7 and 8, and took the temperature of the water of the station meter 9 and of the gas leaving it at 10. This man was responsible for the regulation of the condensers. By the use of cold water for the condensers it was possible to keep the temperature at the inlet of the tar separator from rising above 120° F. after the first few minutes of the test. As the test progressed and less steam came over, the water was cut off. Toward the close of the test steam was turned on the condensers, and, at the last, even with full steam it was not possible to keep the temperatures above 100° F.

METHODS OF SAMPLING AND ANALYSIS.

The sampling of the ammonia, tar, and naphthalene in the gas at the tar separator kept one man extremely busy and requires further description.

AMMONIA.

Sampling.—It was necessary to deviate from the practice, usually followed at gas works, of determining the quantity of ammonia in the liquor flowing from the separator and scrubber, because of the large volume of liquor in these devices at the beginning and the end of a test as compared with the volume collected during the test period of five hours. The ammonia liquor from the condensers was collected each half hour and the ammonia in the gas from the condenser was determined from samples taken at the inlet of the tar separator. The sampling was done by drawing a portion of the gas through bottles containing dilute acid. The aspirator tanks used for the purpose held about a cubic foot of gas, and were adjusted to empty in a half hour, the exact time at the start and the end of each half-hour period being recorded. After the ammonia in the half-hour sample was determined, the quantity of ammonia in the whole volume of gas was computed from the station-meter readings, allowance being made for the few minutes' interval between collection periods. These figures were then, for ready comparison, calculated to even half-hour intervals.

Analysis.—The ammonia in a measured volume of gas at the tar-separator inlet (*b*, fig. 1) was absorbed in 7 per cent sulphuric acid contained in the Wouff bottles, into which it was drawn by an

aspirator of known capacity. The acid solution was then made alkaline, and the ammonia liberated was absorbed in a known volume of standard acid. The acid not neutralized by the ammonia was found by titration against standard alkali. The ammonia in the liquor drawn from the condensing system was determined from weighed 20-gram samples by neutralization and distillation as above.

SAMPLING AND ANALYSIS OF TAR AND GAS FOR NAPHTHALENE.

The tanks, N, S, and T, were connected to the outlet of the large meter and one was filled during each half hour. The connections to these tanks were so arranged that any one tank could be connected either with the gas mains at the meter outlet or with the lines leading to the laboratory, as shown by figure 1. On account of the great analytical labor involved, the naphthalenes in the tar fog and gas at the inlet of the separator were determined only a few times, and those at the outlet in only about half the tests. For the same reason the naphthalene that had been dissolved by the tar in the condenser and the tar separator was determined only in an average sample of the combined tars for the whole distillation period.

The naphthalene in the gas at the outlet, and sometimes at the inlet, of the tar separator was determined by scrubbing or passing a known volume of gas through a saturated picric-acid solution containing 10 per cent of acetic acid, the tar fog being filtered out by an asbestos filter. This tar tube and picric-acid solution were changed as often as the aspirator emptied, and were later removed to the laboratory for analysis. A large excess of alkali was subsequently added to these solutions and the free naphthalene was expelled at 70° C., drawn into a weighed U tube, and there condensed at 0° C.

The naphthalene in the tar suspended in the gas at the inlet and the outlet of the tar separator was determined by heating samples of tar from known volumes of gas to 70° C. until no naphthalene was given off. This naphthalene was drawn into weighed U tubes and there condensed at 0° C.

COLLECTION OF SAMPLES.

For collecting the samples of tar and gas a glass tube about 6 inches long containing fibrous asbestos and glass wool, a bulb tube containing picric-acid solution, and a calibrated aspirator were placed in series and the gas drawn through the system at different rates, determined by the point of sampling. For the standpipe samples, most of which were drawn 4 or 5 inches from the top of the standpipe or on the bridge pipe, an aspirator of about one-third cubic foot capacity was used and the gas was drawn into it at a rate of about

one-third cubic foot per hour. The weighed tube containing the asbestos and glass wool was inserted less than half its length in the hole tapped in the standpipe, because of the high temperature of the gas at this point. When the tube was placed inside the pipe a great deal of tar and oil passed uncondensed through the filter to the picric-acid bulb tube. For taking samples at other points than the standpipe a cubic-foot aspirator was used, the time of drawing a cubic foot of gas being two or three hours. Tar tubes for all these samples were placed inside the main, because the samples collected there would be most comparable to those collected in mains under service conditions.

ANALYSIS.

The analysis of the tar collected in the asbestos filter was conducted as follows: The tube containing tar and water incorporated in the asbestos was weighed, this weight giving by difference the weight of tar and moisture collected. The contents of the tube and, if the tar stuck to the glass, pieces of the glass itself were put into the

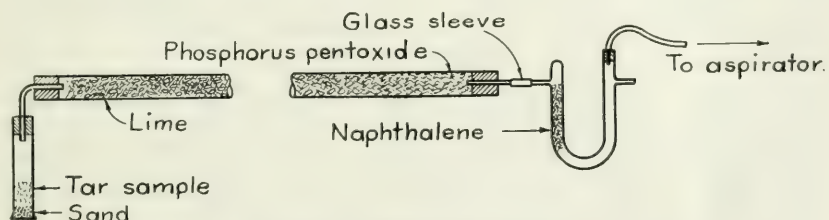


FIGURE 6.—Apparatus for analysis of tar.

volatilizing tube, which was then weighed. The tube was placed in series with the drying train and the naphthalene U tube, as shown in figure 6, and the whole system was put in the oven. The oven was heated to 70°–80° C. and air was slowly drawn through the system, volatilizing the naphthalene and moisture in the tar. The moisture was taken up by the drier—lime and phosphorus pentoxide—and the naphthalene passed on to be frozen out in the U tube, which was placed just outside the oven in a trough containing ice water. The analysis was complete when the weight of the naphthalene U tube remained constant, or very nearly so, at consecutive weighings made after a two or three hour interval. The time required for an analysis varied with the quantity of tar in the sample, but was usually 30 or 40 hours for standpipe samples containing 8 to 10 grams of tar.

When the analysis was completed, the volatilizing tube was again weighed; the loss showed the weight of the moisture and naphthalene given off. From the weight of the naphthalene in the U tube was determined the weight of the moisture also. The moisture determination, however, was at best only approximate, because more or less of the light oils, such as benzol, always escaped from the tar with the

moisture and naphthalene, and the laboratory had no means of determining them. Finally, the volatilizing tube was placed in a Soxhlet extractor and the remaining contents were extracted with chloroform until free of all soluble material. After the tube was dry it was weighed to find the weight of free carbon in the tar.

APPARATUS.

The oven used was of galvanized iron. It was 20 inches high by 16 inches wide by 14 inches deep, and was so arranged that eight samples could be worked at a time. The volatilizing tube was made from a 6-inch test tube cut in two about 4 inches from the top. A piece of muslin was wired over the flare, a layer of sand about one-half inch deep was put in, and the tube was then ready for the contents of the tar filters. The drying train (fig. 6) consisted of a heavy glass tube of about one-half inch internal diameter and 12 inches long, which contained broken lime for about two-thirds of its length and phosphorus pentoxide thoroughly incorporated in glass wool the other one-third. The glass wool prevented the gas from forming channels in the phosphorus pentoxide, and thus aided in rendering the extraction of moisture complete before the gas reached the naphthalene U tube. In order to avoid an excessive expense for phosphorus pentoxide it was necessary to use lime that had an extremely rapid reaction with water. If the lumps of lime were too small, their expansion while slaking cracked the tube. If the lumps were too large, the gas was not dried enough. Connection with the naphthalene U tube was made, as shown in figure 6, through a glass sleeve rendered air tight by an inclosing piece of gum-rubber tubing. The glass kept the naphthalene from coming in contact with the rubber.

REMARKS.

This method of analysis permitted the estimation of water, non-volatile tar, free carbon, and naphthalene. The separation of the water and the anhydrous tar was not very exact, any light oils that were vaporized by the air drawn through the train being reported as water. The determination of naphthalene, however, was precise enough. The air left the drying system saturated with naphthalene at the temperature of ice water, but this loss need not have amounted to over a milligram for each 10-hour run. It is possible that the naphthalene might have been contaminated by other hydrocarbons and, as has been pointed out in an account of previous work at the plant, the naphthalene deposit was sometimes slightly oily and had a low melting point. An attempt was made to determine the nature of this oil, but the small quantity collected rendered the attempt difficult. The oil has been shown to be an unsaturated hydrocarbon,

and it is quite possible the little-known indene, C_9H_8 , a transition product between benzol and naphthalene that has been isolated from the tar distillates which contain most naphthalene. The oil has been found rather abundantly in the analyses of some tar distillates, as would be expected of indene, but is much more plentiful in some tars than in others. In any case, however, the reporting of this oil as naphthalene seemed justifiable, because the oil would be found associated with naphthalene and would separate out with the latter in a gas plant just the same as in the laboratory. It is possible that the presence of this oil may aid in preventing solid deposits of naphthalene, and its occurrence is worthy of note.

HYDROGEN SULPHIDE IN PURIFIED GAS.

The hydrogen sulphide in the gas leaving the ammonia scrubber (j, fig. 1) was determined, in the later tests, by bubbling a portion of the gas slowly through ammoniacal cadmium chloride and then through an experimental meter. The usual lead-acetate test never disclosed the presence of hydrogen sulphide in the purified gas.

YIELD OF COKE.

The standard test charge of 400 pounds of coal was usually carbonized in four and one-half hours, but in case a longer time was needed, carbonization was continued till the evolution of gas from the charge dropped to about 1 cubic foot per minute. The coke was drawn by the stokers into a special buggy placed just below the mouthpiece of the retort, and weighed at once without quenching. It was then quenched, allowed to stand in the buggy for two or three days, and reweighed. The expectation was that some idea would be obtained of the relative quantities of water retained by the cokes from the various coals. Unfortunately, the cokes had to be drowned so completely to prevent their catching fire that they absorbed excessive quantities of water, which they still retained at the second weighing, so that the moisture figures for quenched coke have little value. The wet coke was screened over a three-fourths-inch bar screen in the same manner as the coal, and a representative sample was sent to the Pittsburgh laboratory for analysis.

The analyses reported as dry coke are taken to represent the coke as it was drawn from the retort before quenching, although the analyses of coke as received by the laboratory do not necessarily correspond to the quenched coke, because of an unavoidable loss of moisture during sampling. The percentage of coke substance is figured from the analysis and represents coke free from ash and moisture.

YIELD AND QUALITY OF GAS.

COLLECTION OF SAMPLES.

The two tanks for sampling the purified gas were used alternately and were changed exactly at the close of each half hour. Error due to solubility of the varying gases in the water of the calorimeter and photometer meters was avoided, so far as was possible, by allowing the gas to flow through the meters for 15 minutes to saturate the water before starting the test.

CANDLEPOWER.

The candlepower of each half-hour sample was determined by means of a Lummer-Brodhum contrast photometer mounted on a 2,500-mm. bench. This photometer was equipped with a Sugg D burner and Hefner amyl-acetate lamp. The Sugg D burner was chosen from among the many photometric burners because it is frequently used and does not require the complicated adjustment of the new Metropolitan No. 2 burner, which would probably have been adopted but for the need of rapid work and the widely varying candlepower of the gas. The burner was regulated to burn about 5 feet per hour, although its rate was reduced to 4 feet for the high candlepower samples from the first part of the distillation period.

ANALYSIS.

A sample of gas representing each half-hour period was collected in a special gas holder of the Hempel type, having both inlet and outlet sealed with water columns of small cross section and closed with rubber tubing with screw clamps. If the water previously in the holder had been saturated with gas, and the holder had been so filled with gas that the water and gas were in contact only in the narrow tubes at the top and bottom of the holder, a sample could be kept in a holder for several days in perfect safety.

Gas analyses were made on the half-hour samples by means of the regular Hempel pipettes. Water saturated with illuminating gas was employed as a containing liquid in the measuring burettes. Bromine water was used as an absorbent for illuminants, oxygen was removed by phosphorus, and methane and hydrogen were determined by the explosion method.

The lead-acetate test did not show the presence of hydrogen sulphide in the purified gas.

Only the sulphur present as hydrogen sulphide in the unpurified gas was determined. In the method used the unpurified gas was passed at the rate of about 0.2 foot per hour through an ammoniacal solution of cadmium chloride contained in a Meyer absorption bulb.

MEASUREMENT OF RETORT TEMPERATURES AND PRESSURES.

In tests 18 to 30, temperatures within the retort were taken with a Bristol pyrometer having a 9-foot fire end. The junction of the couple was placed on the surface of the charge $4\frac{1}{2}$ feet from the mouth-piece. In tests 30 to 35, a Hoskins heat gage was used in a similar manner. In tests 18 to 30, the temperatures of the fire space outside the retort were taken with a platinum-rhodium couple inserted into the fire space at 1 (fig. 1), with its junction 2 inches from the retort. In tests 30 to 35, a Hoskins heat gage was used for this purpose. The temperature of the inner surface of the retort walls was sometimes taken before charging and after drawing by means of a Morse thermogage. All pyrometer readings were corrected by frequent calibration at the university laboratory against a standard platinum, platinum-rhodium couple. Temperatures at points 3, 4, 5, 6, 7, 8, 9, and 10 (fig. 1) were taken with thermometers (Fahrenheit scale) calibrated in a water bath against a certified German standard thermometer.

Pressures at *d*, *e*, *h*, *i*, and *k* are expressed in tenths of an inch of water. Notations are made in such cases, as are differential pressure readings.

WEIGHT BALANCE.

The weight balance of the distillation process is the sum of the products recovered plus the loss unaccounted for. The weights of coke, gas, tar, and ammoniacal liquor collected are added, and to this sum is added the computed weight of water vapor, which should condense in the gas separator when the gas is cooled to the standard temperature of 60° F. The computation is readily made by using tables of vapor tension. The difference between the sum of the known products and the weight of the original charge is reported as "Loss unaccounted for."

BASIS OF COMPUTATIONS.

Because this report presents a comparison of the products of the destructive distillation of coals of different composition, especial care has been taken to set forth the characteristics of the products as fully as possible. Many persons consider that such a study should be based on the unit weight of coal charged. Others prefer to base computations on the unit weight of dry coal, but if the study is to be made in a scientific way, the best basis is the unit weight of coal free from moisture and ash.

COINCIDENCE OF OBSERVATIONS.

All operations during a test were performed and all readings were taken, so far as was possible, at the same time at half-hour intervals. It was feasible to collect by exact intervals the samples of tar and ammonia liquor, and also the tank samples of purified gas for candle-

power and heating value determinations and for analysis. The emptying of the tanks used for collecting samples for ammonia and the naphthalene determinations sometimes took more and sometimes less than 30 minutes, but as the observer recorded the exact times at which the emptying began and was complete, it was possible, by reference to the volume of gas registered by the station meter in the interval, to recalculate the results to even half-hour periods without any error other than that involved in the assumption that the constituents being tested had been evolved at a constant rate throughout a given half hour. This assumption might have caused a slight error in the half-hour figures, but could not have affected the totals.

PRESENTATION OF RESULTS.

The important data showing the progress of distillation by half-hour intervals for each coal have been platted in Plate IV and have been brought together for comparative study in Tables 3 to 7. In Plate IV there is given under each test the temperatures inside and outside of the retort, the candlepower and the heating value of the gas, and the variations in the percentages of the important constituents—"illuminants," hydrogen, and methane. The percentages of carbon dioxide, carbon monoxide, oxygen, and nitrogen in the gas were not tabulated nor platted, as they changed little during the distillation.

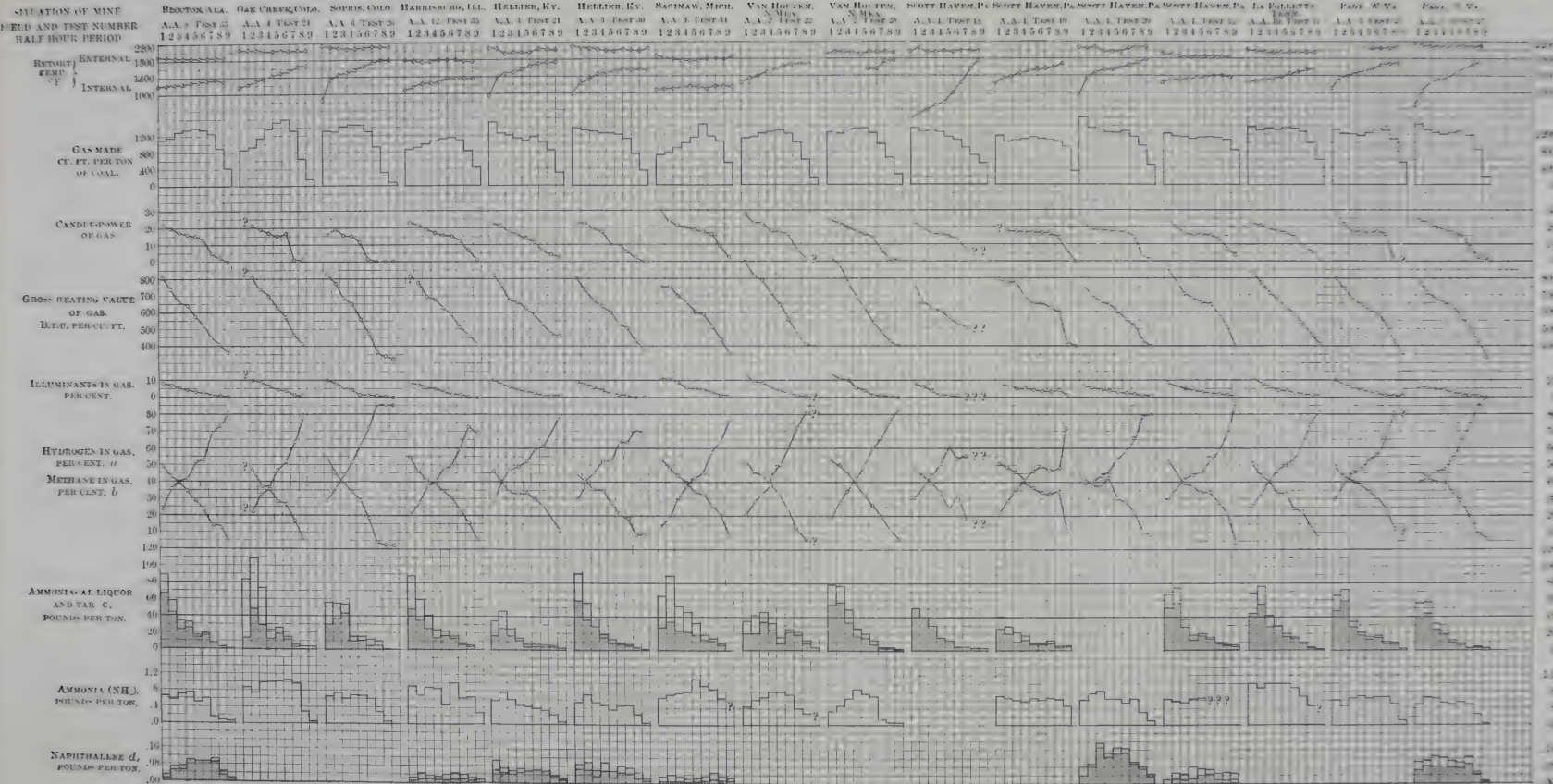
The total yields of tar and ammonia liquor are shown on the chart by half-hour intervals, as are also the yield of ammonia (NH_3) and the weight of naphthalene vaporized in the gas and dissolved in the tar at the outlet of the tar separator. This weight of naphthalene was chosen for presentation because the naphthalene that gets past the tar separator, either vaporized or dissolved, causes trouble, as dissolved naphthalene is set free by the ammonia liquor in the scrubbers.

VERIFICATION OF DATA.

GENERAL STATEMENT.

The preceding presentation of the methods of making tests and computing results should be supplemented by a discussion of the means of determining the accuracy of the results obtained.

There were several ways in which the accuracy of the work might have been checked. One method used was to take a standard coal that should give known results. In order to check the operation of the experiment station plant in this manner, a standard Pittsburg gas coal was procured and the first three tests, as well as a later one, were made on it. The results are discussed in their appropriate places.



PROGRESS OF COAL DISTILLATION BY HALF-HOUR PERIODS.

Another means used for checking results was by comparing duplicate tests of the same coal. An exact duplication of results could hardly be expected because of the number of variable factors involved, but it was sometimes possible to partly explain discrepancies as caused by differing conditions that had been noted during the test.

Valuable evidence of accuracy was obtained by studying the data gathered from a single test in the light of the knowledge gained from other tests. The platted curves showing the rate of formation of gas, ammonia, and tar should show a relation to each other and to the retort temperature, and the curves indicating the candlepower, heat value, and chemical composition of the gas should show some concordance.

A conclusive proof of inaccuracy was sometimes given by the unaccounted-for loss. The total weight of the products should always have been less than the weight of the coal charged, for there was always a loss of products while the retort was open for charging. In the results given in this bulletin some losses that swelled the unaccounted-for totals were the tar that stuck in the standpipe, of which no account was taken; the water removed from the gas in the tar separator or carried in suspension past the separator (which could not be estimated in the small plant used), and the weight of hydrogen sulphide and carbon dioxide removed by the ammonia liquor in the scrubber and purifier. The average total of such unaccounted-for losses in the tests was 6.6 per cent of the coal as charged.

Each of the complete tests recorded here required over 1,800 observations, and, as was to be expected, there may be found in the platted results of almost every test, points so far from their expected positions that they are evidently in error. Fortunately, however, determinations were made every half hour or oftener, so that an error in any one determination had a relatively small effect upon the average result.

It is believed that the care taken in the calibration of pyrometers, thermometers, gas-sampling tanks, and meters prevented any serious systematic errors in measuring temperatures, or in determining the quantity, heating value, chemical composition, or candlepower of the gas. The measuring of the quantity of tar and ammoniacal liquor from any given test is believed to have been fairly accurate, although some of the irregularities in the quantity of tar from one half-hour period to the next may have indicated a temporary stoppage in the drips, and there is a possibility suggested by the results from coals yielding stiff tars that heavy tar collected in the pipes during the latter part of the preliminary run and was washed out by lighter tar during the first part of the regular test, thus unduly increasing the tar in these samples.

AMMONIA.

There was some uncertainty concerning the yield of ammonia, because it had to be determined, as already explained, by sampling the gas at the inlet of the tar separator. The results from the separate tests should certainly be comparable with one another, and the results on the standard Pittsburg coal, though better than those usual in practice, were not high enough to throw serious doubt on their reliability, since the care taken to have the retort in good condition and to keep the exhauster working properly warranted higher than average returns of ammonia and of all other products of distillation.

The theoretical yield of ammonia was calculated from the ultimate analysis of the coal on the assumption that all of the nitrogen found might theoretically be converted into NH_3 . Fourteen parts by weight of N form 17 of NH_3 , and on this basis the Alabama coal, No. 8, with 1.24 per cent nitrogen in the dry coal, should yield theoretically 1.51 per cent ammonia, or 30.1 pounds NH_3 per ton. The actual yield of ammonia was only 4.15 pounds NH_3 per ton, or 13.8 per cent of the theoretical.

NAPHTHALENE.

No great accuracy is claimed for the naphthalene figures on account of the large correction factors involved in the tedious process of analysis. The results should be comparable with one another, but an absolute error of 10 per cent is entirely probable.

QUANTITY AND QUALITY OF GAS.

The weight of gas was computed by multiplying the corrected volume of gas by its weight per cubic foot. The latter figure was calculated from the percentage composition of the gas and the known weights of the constituents—carbon dioxide, hydrogen, etc. For this purpose the "illuminants" were assumed to be ethylene, an assumption not strictly accurate but involving only a slight error. In published tables the weights usually given of the various gases are those calculated for a temperature of 0°C . These values were recalculated to the standard conditions—gas saturated with moisture at a temperature of 60°F . and a barometric pressure of 30 inches.

The values obtained are as follows:

TABLE 2.—Weight per cubic foot of various gases saturated with moisture at 60°F . and 30 inches barometric pressure.

	Pounds.
Carbon dioxide	0.1140
Carbon monoxide	.0726
Ethylene	.0726
Hydrogen	.0052
Methane	.0415
Nitrogen	.0728
Oxygen	.0830

The average heat value, candlepower, and chemical composition of the gas, as calculated from the figures for the nine half hours of the test, were computed by reference to the volume of gas made during each period. Thus, if in one half hour the yield of gas was 250 cubic feet and its heating value was 650 British thermal units, the product of 650 by 250 was taken as the number of heat units produced during the period and was added to the figures similarly obtained for the other periods. The total number of heat units thus obtained divided by the total output of gas gave the average heating value.

This method gave correct averages of heating value and chemical composition. The average candlepower obtained in this way, however, was only approximate, since the candlepower of a gas is a function of two entirely distinct variables—temperature and the amount of free carbon liberated in the flame—and hence the candlepower of a mixture of gases will not usually be the arithmetic mean of the candlepower of the component gases.

COAL AND COKE.

It would seem that the data on coal and coke should be the least liable to error, and yet, partly because of the lack of sensitiveness in the scales used, partly because of the loss in charging and drawing or the possible addition of carbon knocked off the roof of the retort, and possibly because of carelessness in weighing (the simplicity of the operation causing too much reliance to be placed on a single reading), the internal evidence indicates that the largest single errors were those in the weights of the coal and coke. The most exasperating illustration of this fact is found in test 25 on West Virginia coal, where the sum of the products is 101.7 per cent of the weight of the coal. An error so large could hardly have come from any other source than incorrect weighing.

Another error in some of the tests is revealed by comparing the percentages of ash in the coal and coke. If all the experimental tests had been correctly made the calculated per cent of ash in the coke would be the same as the percentage obtained, which was not the case in all the tests. The coke sample taken was carefully crushed and quartered for analysis, but a similar procedure was not followed in sampling the coal because it was not desirable to change the proportion of coarse and fine coal in the sample as it left the screen. The weight to be sampled for each charge was so small and the size of the material so uneven that the coal sampling could not be accurate. The greatest discrepancy in the analyses was, of course, in the ash. In the same way the few sacks of coal used for one test may have had a composition materially different from that of the coal used in a duplicate test and from that of the mine sample.

Attention is called to marked discrepancies of this sort in the notes on the individual tests.

The probable reliability of each test is discussed in the description of the test.

DETAILS OF TESTS.

Eighteen tests on 11 different coals from 10 States are here reported. For convenience of reference the tabulated results are arranged in alphabetical order by States, except that the tests on the standard Pittsburg coal are discussed first because of their value as an index of the reliability of the whole series. The data concerning the analyses and chemical composition of all the coals and cokes are given in Tables 3 and 4. The condensed data of the products of distillation for all the tests are given in Tables 5, 6, and 7. The course of each test as indicated by the retort temperature, rate of gas production, etc., at half-hour intervals, is shown graphically in Plate IV.

The individual tests are discussed in the order shown by the following table:

Order in which tests are discussed.

State.	Place.	Coal bed.	Field No.	Test No.
Pennsylvania.....	Scott Haven.....	Pittsburg.....	A. A. 1	18, 19, 20, 32
Alabama.....	Blocton.....	Thompson-Underwood.....	A. A. 8	33
Colorado.....	Oak Creek.....	Yampa.....	A. A. 4	24
Do.....	Sopris.....	Sopris.....	A. A. 6	26
Illinois.....	Harrisburg.....	No. 5.....	A. A. 12	35
Kentucky.....	Hellier.....	Upper Elkhorn.....	A. A. 3	21, 30
Michigan.....	Saginaw.....	Saginaw.....	A. A. 9	34
New Mexico.....	Van Houten.....	Raton.....	A. A. 2	22, 28
Tennessee.....	La Follette.....	Rex.....	A. A. 10	31
West Virginia.....	Page.....	Kanawha No. 2.....	A. A. 5	25, 27
Wyoming.....	Hanna.....	Lower.....	A. A. 7	23, 29

COAL A. A. 1, FROM PITTSBURG BED, SCOTT HAVEN, PA.

The mine selected to furnish the Pittsburg coal used as a standard in the tests was the Ocean No. 2 mine, working the Pittsburg bed at Scott Haven, Allegheny County, Pa., adjacent to the Pittsburg & Lake Erie Railroad. Mine samples were collected and a car was loaded with screened coal ($\frac{3}{4}$ -inch bar screen) under the supervision of G. S. Pope of the United States Geological Survey. The car was sampled on its arrival in Ann Arbor and about 2 tons were stored in a bin for the tests. The analyses of the coal and the results of the four tests made are given in Tables 3 to 7 (pp. 41 to 46) and in Table 8 (pp. 47 to 50).

The first three tests (18, 19, and 20) were made on this coal as practice tests, and later another test (32) was made to confirm the earlier work. None of these tests was complete, and blanks in the tables indicate that some of the samples were lost or that there was an obvious error in a test. No results were rejected merely because they did not harmonize with the others.

The coal used in the first three of these tests was not screened at the experiment station, but upon reaching a decision to screen all coals the coal in the last test (32) was screened. Tables 1 and 2 show that although 17.4 per cent of the coal was rejected in screening, the composition of the screened coal did not differ much from that of the unscreened. An average of all the results obtained is given in the following table:

Average results of tests of Pittsburg coal.

Coke, per cent of coal charged.....	67.07
Gas per pound of coal charged (cubic feet)	5.04
Candlepower, approximate average.....	15.50
Candle-feet per pound of coal.....	79.50
Heating value per cubic foot (B. t. u.).....	641.00
Heating value per pound of coal (B. t. u.).....	3,280.00
Gas analysis (per cent):	
Carbon dioxide.....	1.30
Illuminants.....	3.70
Oxygen.....	.80
Carbon monoxide.....	6.50
Methane.....	34.40
Hydrogen.....	48.20
Nitrogen.....	5.00
Ammonia (NH ₃) per ton of coal charged (pounds)	5.43
Tar per ton of coal charged (pounds)	155.80

The average results obtained in regular practice at the works of the Ann Arbor Gas Co. with a coal from the same general district were: Coke, 67.8 per cent (of which 8.6 per cent was breeze); gas, 4.95 cubic feet per pound; candlepower of gas, 16.9; heating value of gas, 617 British thermal units per cubic foot.

The tests can be compared best with the aid of the curves platted in Plate IV. By starting at the top of the sheet and reading down, it will be seen that the external retort temperatures varied little during a test, but that the interior retort temperatures varied a great deal. The low starting temperature of the first test (18) is known to have been caused by the pyrometer being bedded in the coal instead of lying on its surface. The curves show plainly the effect of retort temperatures on gas production. The high retort temperatures of tests 18 and 20 caused a rapid but quickly decreasing evolution of gas. The lower retort temperatures drove the gas off more slowly and evenly, but of course the carbonization period had to be longer. During test 19 the retort was badly coated with carbon, which was removed before test 20 was run. The sluggish evolution of gas in test 19 may be partly due to this coating. The coke drawn was good in all four trials, and the two screening tests made showed only 5 per cent and 7 per cent breeze.

The candlepower of the gas was fairly uniform, the gas tenaciously maintaining its candlepower during the middle portion of the run in spite of falling heat values, a characteristic of this Pittsburg coal which may partly account for the fame it has won as a gas coal. In Plate IV the curves of candlepower in the three tests averaged lie near each other, but there is an apparent discrepancy in test 20, where the highest candlepower (16) is found with the highest retort temperatures, and accompanies the highest yield of gas (5.27 cubic feet) with the lowest heating value (611 B. t. u.). The high yield and low heating value of the gas would be expected from the high retort temperature, but the high candlepower seems to be an error, since it is not in accord with the heating value or with the chemical composition of the gas. The curves showing the heat value and the chemical composition of the gas call for little comment. The decrease of the unsaturated hydrocarbons reported as illuminants, the decrease in the methane, and the increase of the hydrogen as the test progresses characterize the gas from all the coals tested.

The tar figures for tests 18 and 19 agree fairly well. The results for test 20 were unfortunately not taken, the tars being thrown out before weighing. The figures for test 19 were spoiled by the outlet of the tar separator clogging. The weight of tar collected from the condenser was normal (66 pounds per ton of coal as compared with 68 pounds, the average of the other two tests), but the tar drawn from the separator weighed only 35 pounds as compared with 111 pounds, the average of the other two tests.

The course of ammonia formation, as shown by the curves, was fairly regular. The curve for test 32 is incomplete because a stoppage of the aspirator tank outlet in the latter part of the test made the emptying of the tank so slow that determinations calculated to half-hour intervals would be misleading, although the figures for total ammonia were unaffected. In test 20 the effect of high retort temperature in cutting down the yield of ammonia at the end of the run is noticeable.

The naphthalene data are complete for test 32 only, and show a total yield of 8.1 pounds of naphthalene per ton of coal, a yield higher than that from any other coal except the West Virginia (11.4 pounds) and the Alabama (10.7 pounds). As with all the coals, a large percentage of the naphthalene was dissolved in the tar. Close attention was paid to the small quantity of naphthalene which escaped solution in the tar, since it is this undissolved naphthalene which may cause trouble. In the test with this coal the quantity of naphthalene left as vapor would have sufficed to saturate the gas at an average temperature of 63° F.

The weight balance for these tests is given in Table 8 (p. 48) and is reproduced here reduced to a percentage basis.

Heat balance of tests of coal A. A. 1.

[Percentages on weight of coal charged.]

	Test 18.	Test 19.	Test 20.	Test 32.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Coke.....	67.1	67.5	64.7	68.5
Gas.....	14.7	16.3	15.4	14.7
Tar.....	8.1	a 5.2		9.9
Ammonia liquor.....		3.4	3.5	3.8
Unaccounted for.....		7.6		3.1
Total.....		100.0		100.0

a Low, as previously stated.

If it had not been for the stopping of the outlet of the tar separator in test 20, which made the tar low and the unaccounted-for loss high on that test, the figures would be in fair agreement, with the unaccounted-for loss between 3 and 4 per cent.

COAL A. A. 8, FROM BLOCTON, ALA.

The sample consisted of 60 sacks of coal from the Blocton No. 7 mine, working the Thompson-Underwood bed at Blocton, Bibb County, Ala. The coal was shipped under the direction of P. M. Riefkin. Tables 3 to 8 summarize the particulars regarding this coal and the one test (33) made on it.

The coal as received was dusty, but showed no pyrite nor slate. The high percentage of coal passing through the $\frac{3}{4}$ -inch bar screen (23.4 per cent) may have resulted from frequent handling of the sacks in transit. Screening improved the quality of the coal, the ash content of the refuse being 14.50 per cent, though that of the screened coal was only 4.29 per cent. The percentages of moisture, ash, and sulphur were low, and the volatile matter was less than in most of the coals tested, being only 29.1 per cent in the coal as charged.

The regular charge, 400 pounds, of screened coal was put into the retort, which had an external temperature about the average of the tests. The internal temperature remained low, however, and gas came off slowly, the rate not reaching a maximum till the fifth half hour. At the end of the ninth half hour distillation was practically complete. The coke was reported as not having a good appearance and showing some slate; but the percentage of breeze was only 12.5 per cent, and the total yield and the ash content were about the same as for the Pittsburg coal. The yield of gas (5.18 cubic feet per pound) was good; the initial candlepower (21.8) and heating value (612 B. t. u.) were satisfactory, but the quality fell off so rapidly that the average candlepower (14) and heating value (598 B. t. u.) were rather low. These averages give by calculation 72.5 candle-feet per pound of coal and 3,100 British thermal units in the gas per pound of coal. Both values are distinctly lower than those from the Pittsburg coal.

The runs of tar and ammonia liquor were regular. The total yield of ammonia (NH_3) was low, only 4.03 pounds per ton of coal, scarcely any being evolved during the last three half hours. The poor return was due in part to the low nitrogen content (1.24 per cent) of the dry coal. The percentage recovered was also low, being 13.8 per cent of the theoretical as compared with an average recovery for all the coals tested of 16.8 per cent. The total production of naphthalene was high, but the tar was evidently able to absorb it, so that the saturation temperature of the gas leaving the tar separator was only 57°F . The weight balance with its unaccounted-for loss of 1.7 per cent is too low, but the test is believed to be reliable. The coal deserves further investigation.

COAL A. A. 4, FROM OAK CREEK, COLO.

The sample consisted of 59 bags of run-of-mine coal from the Yampa bed of the Oak Hill mine, on the Denver, Northwestern & Pacific Railroad, at Oak Creek, Routt County, Colo. K. M. Way, of the United States Geological Survey, collected the mine samples and supervised the loading of the coal tested. The composition of the coal and the results of test 24 are given in Tables 3 to 8.

The coal had a dull luster, was clean, and showed very little slate and no pyrite. Rough handling in transit may partly account for 39.5 per cent of the coal passing the $\frac{3}{4}$ -inch bar screen. Evidently, however, the ash content was not uniform, for although the two mine samples showed only 8.3 per cent and 9.2 per cent ash in the dry coal, the sample from the sacks contained 15.67 per cent ash and the correctness of the determination is checked by the 25.65 per cent ash in the dry coke. A test for coke only (24 A) gave a coke with only 12.77 per cent ash, or as low as was to be expected from the mine sample.

The coal is notable for the high percentage of moisture it holds tenaciously. Even after air drying it held 4.59 per cent, and as charged it contained 7.17 per cent. The volatile matter in the screened coal, air dried, was 34.8 per cent; though high, it does not adequately show the difference between this and the Pittsburg coal. The ultimate analysis, with an oxygen to hydrogen ratio of 2.67 for this coal against a ratio of 1.28 for the Pittsburg coal, shows the difference better.

The 400-pound sample was placed in a hot retort, but vaporization of the moisture in the coal kept down the retort temperature during the early part of the distillation period. The yield of gas was low at first, but increased as the temperature rose, reaching its maximum in the sixth half hour and then falling off rapidly. The yield was fair, being 4.81 cubic feet per pound of coal as charged and 5.2 cubic feet per pound of dry coal. The gas of the first half hour period was accidentally contaminated with air in the sampling tank, so

that the platted results of the candlepower and heat-value tests for that period are not reliable. The candlepower for the second half hour was 21.7, and the gross heat value 802 British thermal units. The calculated average candlepower and heating value, figures for the lost sample being interpolated, are 14 candlepower and 626 British thermal units. A probable explanation of the low candlepower and heating value of the gas is that the coal, calculated to an ash and moisture-free basis, contains 13.7 per cent oxygen, and Pittsburg coal contains only 7.18 per cent. This high oxygen content must cut down the percentage of hydrocarbons in the gas and increase the proportion of the less valuable oxygen compounds.

The yield of coke, calculated to a dry coal basis, was rather low, a result of the high percentage of volatile matter and the proportion of oxygen in the coal. The excessive proportion of breeze probably resulted from the great shrinkage in coking caused by the above factors.

The yield of ammoniacal liquor during the first three half-hour periods was very heavy, but after that fell off rapidly. The total yield of ammonia (NH_3) was large, 7.6 pounds per ton of coal as charged. In explanation it should be stated that the coal contained 1.59 per cent of nitrogen, calculated to a dry-coal basis, or 25 per cent more than the sample of Pittsburg coal tested. The nitrogen content partly accounts for the high yield of ammonia, but the proportion of the total nitrogen converted into ammonia (22.6 per cent) was higher than in any other test. Low temperature within the retort from the vaporization of the moisture in the coal probably caused this high recovery, as the yield of ammonia scarcely began to decline until after the seventh half hour, when the temperature in the retort was slightly above $1,600^\circ \text{F}$.

The weight balance shows an average unaccounted-for loss of 5 per cent, and the test appears reliable. Apparently this coal can not be classified as a good gas coal.

COAL A. A. 6, FROM SOPRIS, COLO.

The sample consisted of 58 sacks of run-of-mine coal from the Sopris bed, at Sopris, on the Colorado & Southern Railroad, Las Animas County, Colo. The sacks were filled from cars in the railroad yards. K. M. Way inspected the mine and shipped the samples. The composition of the coal and the data of the one test (26) made on it are given in Tables 3 to 8.

The coal as received looked clean, and contained little slate and no pyrite. It had stood shipment well and the proportion that passed through the $\frac{3}{4}$ -inch bar screen was only 13.8 per cent. The analysis of the coal as charged shows 18.1 per cent ash, but the sample probably was not representative since the coke contained only 20.66

per cent ash and the mine samples only 10.9 and 12.4 per cent ash, respectively. Even if allowance is made for the high ash, the content of volatile matter is extremely low, being only 29.8 per cent for coal ash and moisture free, whereas the Pittsburg coal shows over 36 per cent on the same basis.

The charge, 410 pounds of screened coal was put in an extremely hot retort, the hottest used in the tests. Gas production soon reached a maximum, and fell rapidly after the sixth half hour, so that the yield in the last two half hours was extremely small. The yield of coke was large, (75 per cent of the weight of the coal as charged), a natural result of the small percentage of volatile matter in the coal.

The coke was good; only 10 per cent being breeze. The yield of gas was 4.9 cubic feet per pound of coal, but the gas averaged only 12 candlepower and 614 British thermal units per cubic foot; hence the calculated candle-feet were only 58.8 per pound of coal, though the heating value was better, 3,008 British thermal units per pound of coal.

The ammonia liquor was about normal in quantity. The yield of ammonia was low, only 4.35 pounds per ton of coal charged, since the coal is poor in nitrogen. The run of tar declined rapidly after the third half hour and the total quantity was small. No naphthalene tests were made. The weight balance shows an unaccounted-for loss of 1.2 per cent.

This test is apparently reliable. A large yield of gas can hardly be expected from a coal so low in volatile matter as this one; on the other hand, the average candlepower and heat value of the gas would probably have been higher had the retort been cooler.

COAL A. A. 12, FROM HARRISBURG, ILL.

This coal was collected by P. M. Riefkin, from the No. 4 mine, at Harrisburg, Saline County, Ill., on the Big Four Railroad. The shipment consisted of 60 sacks of coal screened over a $\frac{3}{4}$ -inch bar screen. Analyses of the coal and the results of test 35 are given in Tables 3 to 8. Detailed statements of observations made and data computed are given on pages 51 to 75.

The coal as received looked dusty, but no slate or pyrites were noted. It tended to break in finger form, and on rescreening ($\frac{3}{4}$ -inch bar screen) 27.9 per cent of it passed through. The proportion of volatile matter was greater than in any other coal tested—34.4 per cent in the coal as charged, and 39.1 per cent in coal dry and free from ash. The sulphur was also high, 1.96 per cent in the coal as charged. The coal contained more oxygen and slightly more nitrogen than the Pittsburg coal.

The 400 pounds of screened coal were put into a retort, having the lowest temperature of any used in the tests and rather thickly

coated with carbon on the crown. Because of these conditions, the evolution of gas did not reach a maximum until the fifth half hour; it was practically complete at the end of the ninth half hour. The coke was dark and easily broken but gave only 6.7 per cent breeze. The yield of gas was low—4.3 cubic feet per pound of coal. The average candlepower was 15.2, and the candle feet were 65.3. It is possible that had the retort temperature been high the yield of gas would have been greater, but it is also probable that the candlepower of the gas would have been less. The heating value of the gas, 632 British thermal units per cubic foot, was fair; the value per pound of coal, 2,718 British thermal units, was low.

The quantity of ammoniacal liquor was large, partly because the percentage of moisture and combined oxygen in the coal were both somewhat above the average. It is probable also that the low retort temperature prevented the free formation of carbon monoxide and hydrogen. The ammonia yield was large, the percentage of nitrogen in the coal being somewhat above the average; the recovery was 19 per cent of the theoretical as against an average recovery of 17 per cent for all tests. The naphthalene yield was extremely small, perhaps because of the low retort temperature. The content of hydrogen sulphide in the gas at the outlet of the scrubber was 50 per cent more than in the gas from the Pittsburg coal, but was not so high as from some other coals containing much less sulphur. The weight balance shows an unaccounted-for loss of 8.8 per cent, slightly the largest of the series.

The test is apparently reliable. The coal should be tested again at a higher temperature.

COAL A. A. 3, FROM HELLIER, KY.

The sample consisted of about 2 tons taken from a carload of run-of-mine coal shipped from the Upper Elkhorn bed at Hellier, Pike County, Ky., on the Chesapeake & Ohio Railroad. The mine samples were collected by G. S. Pope, who also saw to the shipment of the coal. The composition of the coal and the results of tests 21 and 30 are given in Tables 3 to 8.

The coal as received contained some slate and a large proportion of small-sized material. With a $\frac{1}{2}$ -inch bar screen the screenings came to 30.8 per cent, and with the regular $\frac{3}{4}$ -inch bar screen to 48.5 per cent. The analysis does not differ much from that of the standard Pittsburg coal, although the percentage of oxygen is higher.

In test 21 a light charge, 360 pounds, was placed in a rather hot retort on the advice of the gas-works foreman who had tried some coal from the carload and had found that the volatile matter did not burn off readily. The effect of this light charge is shown in the

platted curve of gas yield (Pl. IV), which drops decidedly after the first half hour.

In test 30 when a regular charge, 400 pounds, was used, the curve of gas yield is more like those platted from the tests of other coals. The coke was 69.4 per cent of the weight of the light charge, and 64.5 per cent of the heavier charge. The difference, though rather large, is in the logical direction. The coke was of good quality, only 9 per cent being classified as breeze.

The yield of gas in the first test was 4.81 cubic feet per pound of coal. The average candlepower was 14.5 and the average heating value 650 British thermal units. In the second test the yield was 5 cubic feet per pound of coal, the average candlepower was 14.1, and the heating value was 622 British thermal units per cubic foot. The figures for candle-feet per pound of coal (69.7 and 70.5) agree well, as do those for the heating value of the gas per pound of coal (3,126 and 3,110 B. t. u.).

The quantities of ammonia liquor in the two tests were about the same but the runs of tar differed, the larger charge giving decidedly more. The ammonia yield was low in both tests, 4.02 and 4.07 pounds per ton. The recovery was about 15 per cent of the theoretical—rather below the average. Naphthalene was determined only in test 30; the quantity was small. Hydrogen sulphide was determined in test 30 in the unpurified gas leaving the ammonia scrubber; the percentage was practically the same as for the Pittsburg coal, which averaged rather higher in sulphur. The weight balance shows an unaccounted-for loss of 5.6 per cent in one test and 7.7 per cent in the other.

The tests are concordant, and seem reliable. The coal is reported to have been used commercially as a gas coal. It promises well.

COAL A. A. 9, FROM SAGINAW, MICH.

The sample consisted of 43 sacks shipped from the Barnard mine, working the Saginaw bed, at Saginaw, Mich., on the Michigan Central Railroad. Perry Barker, of the United States Geological Survey, collected the mine samples and saw to the shipment of the coal tested. The data relating to this coal are to be found in Tables 3 to 8. Only one test (34) was made.

The coal had not been badly broken in shipment; the lumps showed some slate and a noticeable amount of pyrite. On screening, 9.7 per cent of the material passed through the $\frac{3}{4}$ -inch bar screen. The coal as received held 9.28 per cent of moisture and even after air drying carried 4.71 per cent. The ratio of volatile matter to fixed carbon was higher than in the Pittsburg coal. The ratio of oxygen to hydrogen was 1.71, compared with 1.28 for the Pittsburg coal.

A 400-pound charge of screened coal was put into a retort having a temperature decidedly below the average. The interior temperature of the retort remained low throughout the test; hence the yield of gas started slowly and did not reach its maximum until the sixth half hour. The yield of coke was 59.5 per cent; the coke contained 17.9 per cent breeze. The output of gas was low, only 4.3 cubic feet per pound of coal, but the average candlepower of the gas was 17.4, so that the candle feet were 74.8. On the other hand, the average heating value was only 593 British thermal units per cubic foot. The maximum rate of gas production coming at the middle of the test when the heat value of the gas had dropped below 600 British thermal units was one cause of this low average heat value, though even at the beginning the heat value was not very high. The combination of low yield and heating value gave the gas the extremely low average heat value of 2,550 British thermal units per pound of coal.

The quantity of ammonia liquor was large, a logical result of the high moisture content of the coal. The run of tar was about normal. The yield of ammonia was high, 6.40 pounds on the coal as charged, and 21.1 per cent of the theoretical yield. The high recovery probably resulted from the low retort temperature, which lessened the decomposition of the ammonia. The quantity of naphthalene was small. The proportion of hydrogen sulphide at the outlet of the scrubber was very large, 3,750 grains per cubic foot, or more than four times as much as from the Pittsburg coal, which contained about the same percentage of sulphur. The weight balance shows the unaccounted-for loss to be 8.5 per cent, or a little more than the average for all tests, 6.6 per cent.

The results throughout are concordant and the test seems reliable. This coal does not promise well as a gas coal, but it must be remembered that the low retort temperature had an unfavorable effect.

COAL A. A. 2, FROM VAN HOUTEN, N. MEX.

The sample consisted of 58 sacks of run-of-mine coal from the Raton bed, at Van Houten, Colfax County, N. Mex., on the Santa Fe Railroad. The mine sampling and the shipment of the sacks were under the supervision of K. M. Way. The usual analyses and the results of tests 22 and 28 are given in Tables 3 to 8.

The coal as received was rather fine, possibly because of the handling of the sacks in transit, but was clean, with a good luster. It showed little slate and no pyrite. Results of screening tests differed decidedly; in one test 11.95 per cent was rejected and in the other 21.90 per cent. The analyses of the two samples of coal gave similar discrepancies in the ash content, 15.1 per cent in test 22 and 8.94 per cent in test 28; the differences were corroborated by the ash content

of the coke, 22.6 per cent in test 22 and 17.66 per cent in test 28. The ash in the mine samples fell between the extremes shown by the samples taken at the plant, being 10 per cent and 12.7 per cent, respectively. The composition of the coal, aside from the ash, was not much unlike that of the Pittsburg coal.

The retort temperatures were moderately high. The yield of coke was about the same as from the Pittsburg coal. The proportion of breeze was small, averaging 12.5 for the two tests. The curves showing the gas yield and the variation in the composition of the gas (see Plate IV) are almost identical for the two tests. The candle-power of the gas (16.5 and 16.8) and its heat value (674 and 682 B. t. u.) agree well in the two tests.

The yield of gas was less on test 22 (4.5 against 4.9 cubic feet). On eliminating the effect of the higher ash in the coal of test 22 by calculating the yield to an ash and moisture free basis, the discrepancies disappear and the yield becomes 5.5 cubic feet per pound of coal in each case.

The runs of ammoniacal liquor and of tar are higher in test 28 than in test 22, and as the total products in test 28 add up to more than the weight of the coal charged, it is possible that the recorded weight of coal charged is wrong and should have been about 10 pounds higher. The yield of ammonia was larger in test 22 (4.98 pounds per ton) than in test 28 (4.34 pounds per ton). The loss in test 28 came in the last three half hours, where scarcely any ammonia was evolved. There may have been an error here, although there is nothing in the data to prove it. The weight balance shows an unaccounted-for loss of 5 per cent in test 22 and a negative loss of 0.3 per cent in test 28, as mentioned above. The fact that the yields of coke, gas, tar, and ammoniacal liquor are all higher in test 28 than in test 22 is another indication that the reported weight of the coal charged into the retort in test 28 was too low.

This coal in the tests gave as good results as Pittsburg coal, and well deserves further investigation by gas companies in the Southwest.

COAL A. A. 10, FROM LA FOLLETTE, TENN.

The sample consisted of 60 sacks of coal from the Rex bed, at La Follette, Campbell County, Tenn., on the Louisville & Nashville Railroad. P. M. Riefkin inspected the mine and supervised the shipment of the sample. The composition of the coal and the results of test 31 are given in Tables 3 to 8.

The coal as received was bright and clean with no pyrite or slate evident. Only 8.37 per cent of the shipment passed through the $\frac{3}{4}$ -inch bar screen. The coal as sampled and analyzed at the plant showed a low moisture content and the extremely low ash content of

2.15 per cent, though the mine samples contained 5 and 7 per cent of ash, respectively. Except for the ash the proximate analysis of the coal is not very different from that of the Pittsburg coal, but the ultimate analysis shows 20 per cent more oxygen and a high percentage of nitrogen.

The usual charge, 400 pounds, of screened coal was placed in a moderately hot retort. The percentage of coke and of screenings were about the same as for the Pittsburg coal, although the coke seemed more fragile. The evolution of gas was regular. The total yield of gas was high, 5.5 cubic feet per pound of coal as charged, but the yield if calculated to a basis of coal ash and moisture free is only slightly higher than the average results from the Pittsburg coal. The candlepower (15.9) and heat value (641 B. t. u.) of the gas are also fairly comparable with the results from the latter coal. The platted curves showing the evolution of ammoniacal liquor and tar (Pl. IV) are regular. The yield of ammonia was high (7.39 per cent), largely from the high nitrogen content of the coal; the actual yield was only 17.9 per cent of the theoretical while the average proportion for all the tests was 16.8 per cent. No naphthalene tests were made. The percentage of hydrogen sulphide in the unpurified gas at the outlet of the scrubber was low. There may be some relation between it and the high percentage of ammonia, because of the removal of hydrogen sulphide by ammonia in the scrubber. The weight balance shows the rather low unaccounted-for loss of 2.1 per cent.

The test seems reliable and the coal deserves further examination.

COAL A. A. 5, FROM KANAWHA NO. 2 BED, PAGE, W. VA.

The sample consisted of 67 sacks of run-of-mine coal from the Kanawha No. 2 bed at Page, Fayette County, W. Va., on the Virginia Railway. G. S. Pope inspected the mine and shipped the sample. Tables 3 to 8 give the analyses of the samples and the results of tests 25 and 27.

The coal as received was in fine lumps, fairly clean and with no slate or pyrite evident. Screening ($\frac{3}{4}$ -inch screen) removed a large proportion of the coal, 63.27 per cent in one trial and 70 per cent in the other, but the composition of the screenings and of the screened coal differed very little. The average ash content was 6.20 per cent in the coal passing over the screen, and 6.57 per cent in that falling through. This coal had a low percentage of volatile matter and a notably low content of oxygen, the lowest found in any of the coals tested.

Two distillation tests were made, the retort being hot, and the conditions nearly the same in each. The yield of coke was high, a result from the low percentage of volatile matter in the coal, but was distinctly too high in test 25, the figure being 75.5 per cent, as

against 71.25 per cent in test 27. The sum of the products of distillation in test 25 is 101.7 per cent of the weight of coal charged and the yields were uniformly higher, with the single exception of the ammonia liquor, in test 25 than in test 27. The obvious explanation is that the actual weight of the coal charged was more than the recorded weight. The stated yields of gas (5.20 and 5.5 cubic feet per pound), the candlepower (15.8 and 16.1), the candle-feet (82.2 and 80.5), and the heat values (617 and 622 B. t. u. per cubic foot, and 3,208 and 3,110 B. t. u. per pound of coal), check fairly well. They would agree better if the stated weight of coal charged in test 25 were correct. The yield of ammonia was noticeably higher in test 25 (5.19 pounds per ton) than in test 27 (4.38 pounds per ton). The apparent error in the weight of coal charged may partly account for the difference.

Naphthalene was determined in test 27 and the result was the highest of any of the coals. Hydrogen sulphide in the unpurified gas at the outlet of the scrubber was determined in one test; it was twice as much as for the Pittsburg coal, though the latter did not contain a correspondingly higher percentage of sulphur. The weight balance of test 27 was about normal.

These tests tend to confirm the apparently prevalent opinion that West Virginia coals in general give good gas but yield much naphthalene. Another opinion that they produce a pitchy tar which stops standpipes, could not be tested in the short runs made. Although the yield of naphthalene was large, the quantity in the gas at the outlet of the tar separator was not larger than in one of the tests with Pittsburg coal.

COAL A. A. 7, FROM HANNA, WYO.

The sample consisted of 59 sacks of coal from the No. 2 (or lower) bed at Hanna, Carbon County, Wyo., on the Union Pacific Railroad. The sacks were filled from the railway cars as they left the tippie. K. M. Way inspected the mine and supervised the loading of the sample. The usual test data are given in Tables 3 to 8. The coal stood shipment well, though somewhat dusty when received; it showed no pyrite or slate. Only 10.4 per cent of the coal went through the $\frac{3}{4}$ -inch bar screen.

This coal was selected from a desire to test some of the high oxygen coals from the West, and this one with its 32.26 per cent of volatile matter seemed to be promising. The fact that the volatile matter was accompanied by 22 per cent of moisture was overlooked. The tests gave results of scientific interest, although the coal can not be considered in any sense a gas coal. The contained volatile matter figured to an ash and moisture free basis amounted to 44.04 per cent. The oxygen content was 18.93 per cent, and the ratio of oxygen to

hydrogen in this coal was 3.50 as compared with 1.28 in the Pittsburg coal.

Two tests were made on this coal, the first one (No. 23) resulting badly. During the test, owing to a leak in the water line, the seals were blown twice, allowing the purifier to fill with water. Before the leak could be remedied the recorded yield of gas became hopelessly inaccurate. When the retort was opened at the end of the run, the coke was so fine that it flew in sparks all over the retort house. A later test on this coal was made to get more accurate data, but no attempt was made to take a full set of observations.

Test 29 gave the following results: Coke, 50.2 per cent; gas, 5.4 cubic feet per pound of coal; candlepower of gas, 8.8; heat value of gas, 564 British thermal units per cubic foot. The determinations of candlepower and heat value were on gas taken from the proportional tank, and the gas in this tank tends to give rather high results. The ammonia yield was low, 3.77 pounds per ton of coal. The weight balance showed a very high unaccounted-for loss, 14.3 per cent. This loss is probably due in part to coke lost in drawing, and in part to the high oxygen content of the coal causing the formation of much carbon dioxide which was lost in the ammonia scrubber. Even so there was 7.6 per cent of carbon dioxide in the purified gas.

TABULATED RESULTS.

TABLE 3.—Comparative analyses of coal and coke.

Test number and character of fuel.	Proximate analysis.					Heat value (B. t. u.).	Ultimate analysis.					
	Moisture.	Ash.	Volatile matter.	Fixed carbon.	Sulphur.		Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.	Ash.
Test 18 (A. A. 1).												
Coal:												
As received.....	1.92	6.41	32.82	58.85	1.12	14,026	.....	.....	.....	.....	.....	.....
Dry.....	.....	6.54	33.46	60.00	1.14	14,301	5.24	79.00	1.38	6.72	1.14	6.52
Moisture and ash free.....	.....	.....	35.80	64.20	1.22	15,302	5.61	84.51	1.48	7.18	1.22	.....
Coke:												
As received.....	8.54	11.46	.97	79.03	.84	11,552	.....	.....	.....	.....	.....	.....
Dry.....	.....	12.53	1.06	86.41	.92	12,631	.....	.....	.....	.....	.....	.....
Moisture and ash free.....	.....	.....	1.21	98.79	1.05	14,440	.....	.....	.....	.....	.....	.....
Test 19 (A. A. 1).												
Coal:												
As received.....	2.18	7.53	32.96	57.33	1.43	13,815	.....	.....	.....	.....	.....	.....
Dry.....	.....	7.70	33.70	58.60	1.46	14,123	.....	.....	.....	.....	.....	.....
Moisture and ash free.....	.....	.....	36.51	63.49	1.58	15,300	.....	.....	.....	.....	.....	.....
Coke:												
As received.....	18.23	9.00	1.22	71.55	.69	10,543	.....	.....	.....	.....	.....	.....
Dry.....	.....	11.01	1.49	87.50	.84	12,893	.....	.....	.....	.....	.....	.....
Moisture and ash free.....	.....	.....	1.67	98.33	.94	14,488	.....	.....	.....	.....	.....	.....
Test 20 (A. A. 1).												
Coal:												
As received.....	2.05	6.68	33.25	58.02	1.49	13,955	.....	.....	.....	.....	.....	.....
Dry.....	.....	6.82	33.94	59.24	1.52	14,247	.....	.....	.....	.....	.....	.....
Moisture and ash free.....	.....	.....	36.42	63.58	1.63	15,289	.....	.....	.....	.....	.....	.....
Coke:												
As received.....	27.97	8.17	.64	63.22	.80	9,207	.....	.....	.....	.....	.....	.....
Dry.....	.....	11.34	.89	87.77	1.11	12,782	.....	.....	.....	.....	.....	.....
Moisture and ash free.....	.....	.....	1.00	99.00	1.25	14,416	.....	.....	.....	.....	.....	.....

TABLE 3.—Comparative analyses of coal and coke—Continued.

Test number and character of fuel.	Proximate analysis.					Heat value (B. t. u.).	Ultimate analysis.					
	Moisture.	Ash.	Volatile matter.	Fixed carbon.	Sulphur.		Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.	Ash.
Test 21 (A. A. 3).												
Coal:												
As received	2.46	6.25	31.18	60.11	.43	13,885						
Dry		6.41	31.97	61.62	.44	14,234	5.01	79.73	1.22	7.56	.55	5.93
Moisture and ash free			34.16	65.84	.47	15,210	5.32	84.75	1.30	8.05	.58	
Coke:												
As received	12.43	10.09	.92	76.56	.36	11,210						
Dry		11.52	1.05	87.43	.41	12,802						
Moisture and ash free			1.19	98.81	.46	14,468						
Screenings:												
As received	4.30	12.67	26.88	56.15	.46	12,578						
Dry		13.24	28.09	58.67	.48	13,144						
Moisture and ash free			32.38	67.62	.55	15,149						
Test 22 (A. A. 2).												
Coal:												
As received	2.23	15.10	31.42	51.25	.67	12,438						
Dry		15.44	32.14	52.42	.69	12,722	5.08	73.68	1.28	6.01	1.22	12.73
Moisture and ash free			38.01	61.99	.82	15,046	5.82	84.43	1.47	6.88	1.40	
Coke:												
As received	22.30	17.56	.58	59.56	.31	8,681						
Dry		22.60	.75	76.65	.40	11,173						
Moisture and ash free			.97	99.03	.52	14,434						
Screenings:												
As received	2.48	14.78	32.01	50.73	.70	12,335						
Dry		15.16	32.82	52.02	.72	12,648						
Moisture and ash free			38.68	61.32	.85	14,909						
Test 24 (A. A. 4).												
Coal:												
As received	7.17	14.55	32.36	45.92	1.00	10,953						
Dry		15.67	34.86	49.47	1.08	11,799	4.66	70.41	1.59	12.44	1.58	9.32
Moisture and ash free			41.34	58.66	1.28	13,991	5.14	77.65	1.75	13.72	1.74	
Coke:												
As received	21.39	19.93	1.40	57.28	.68	8,417						
Dry		25.35	1.78	72.87	.87	10,706						
Moisture and ash free			2.38	97.62	1.17	14,342						
Screenings:												
As received	6.79	6.50	34.52	52.19	1.52	12,272						
Dry		6.97	37.03	56.00	1.63	13,165						
Moisture and ash free			39.80	60.20	1.75	14,152						
Test 25 (A. A. 5).												
Coal:												
As received	1.28	5.57	30.65	62.50	1.53	14,531						
Dry		5.64	31.05	63.31	1.55	14,720	5.09	82.46	1.42	4.95	.83	5.25
Moisture and ash free			32.91	67.09	1.64	15,601	5.37	87.03	1.50	5.22	.88	
Coke:												
As received	22.59	9.37	.38	67.66	.66	9,855						
Dry		12.10	.49	87.41	.85	12,731						
Moisture and ash free			.56	99.44	.97	14,485						
Screenings:												
As received	1.50	7.71	29.45	61.34	1.45	14,161						
Dry		7.83	29.90	62.27	1.47	14,377						
Moisture and ash free			32.44	67.56	1.59	15,599						
Test 28 (A. A. 2).												
Coal:												
As received	2.32	8.94	32.18	56.56	.70	13,385						
Dry		9.15	32.95	57.90	.72	13,703						
Moisture and ash free			36.27	63.73	.79	15,082						
Coke:												
As received												
Dry												
Moisture and ash free												
Screenings:												
As received	2.22	9.47	34.31	54.00	.51	13,318						
Dry		9.68	35.09	55.23	.52	13,621						
Moisture and ash free			38.85	61.15	.58	15,080						

TABLE 3.—Comparative analyses of coal and coke—Continued.

Test number and character of fuel.		Proximate analysis.					Heat value (B. t. u.).	Ultimate analysis.				
		Moisture.	Ash.	Volatile matter.	Fixed carbon.	Sulphur.		Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.	Ash.
Test 29 (A. A. 7).												
Coal:												
As received	22.56	5.81	32.26	39.37	.36	9,592						
Dry		7.50	41.66	50.84	.46	12,386	5.03	68.80	1.08	17.58	.42	7.09
Moisture and ash free			45.04	54.96	.50	13,390	5.41	78.05	1.16	18.93	.45	
Coke:												
As received	16.25	11.49	1.06	71.20	.34	10,447						
Dry		13.72	1.27	85.01	.41	12,474						
Moisture and ash free			1.47	98.53	.48	14,458						
Screenings:												
As received	11.45	6.13	37.06	45.36	.32	10,939						
Dry		6.92	41.85	51.23	.36	12,353						
Moisture and ash free			44.96	55.04	.39	13,271						
Test 26 (A. A. 6).												
Coal:												
As received	.71	18.32	24.14	56.83	.57	12,436						
Dry		18.45	24.31	57.24	.58	12,524	4.48	72.83	1.07	6.46	.66	14.50
Moisture and ash free			29.81	70.19	.71	15,358	5.24	85.18	1.25	7.56	.77	
Coke:												
As received	23.09	15.89	.73	60.29	.38	8,998						
Dry		20.66	.95	78.39	.49	11,700						
Moisture and ash free			1.20	98.80	.62	14,747						
Screenings:												
As received	1.45	17.98	24.44	56.13	.56	12,407						
Dry		18.24	24.80	56.96	.57	12,589						
Moisture and ash free			30.33	69.67	.70	15,397						
Test 31 (A. A. 10).												
Coal:												
As received	3.13	2.15	34.99	59.73	.72	14,245						
Dry		2.22	36.12	61.66	.74	14,706	5.00	78.14	1.67	8.30	1.83	5.06
Moisture and ash free			36.94	63.06	.76	15,039	5.27	82.30	1.76	8.74	1.93	
Coke:												
As received	26.80	4.45	.86	67.89	.51	10,094						
Dry		6.08	1.17	92.75	.70	13,790						
Moisture and ash free			1.25	98.75	.75	14,683						
Screenings:												
As received	3.21	5.21	33.99	57.59	1.21	13,750						
Dry		5.38	35.12	59.50	1.25	14,207						
Moisture and ash free			37.12	62.88	1.32	15,016						

TABLE 4.—Analyses and composition of coals.

COAL AS CHARGED.

Test No.—	Proximate analysis.					Heat value (B. t. u.).
	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	
33.	2.71	29.13	63.87	4.29	.50	13,990
24.	7.17	32.36	45.92	14.55	1.00	10,953
26.	1.70	23.90	56.26	18.14	.57	12,312
35.	4.66	34.44	53.71	7.19	1.96	12,919
21.	2.46	31.18	60.11	6.25	.43	13,885
30.	3.17	32.40	60.67	3.76	.45	14,200
34.	9.28	31.67	53.70	5.35	.98	12,456
22.	2.23	31.42	51.25	15.10	.67	12,438
28.	2.32	32.18	56.56	8.94	.70	13,385
18.	1.92	32.82	58.85	6.41	1.12	14,026
19.	2.18	32.96	57.33	7.53	1.43	13,815
20.	2.05	33.25	58.02	6.68	1.49	13,955
32.	2.43	32.70	59.99	4.88	.85	14,036
31.	3.13	34.99	59.73	2.15	.72	14,245
25.	1.28	30.65	62.50	5.57	1.53	14,531
27.	1.27	29.02	62.88	6.83	1.18	14,344
29.	22.56	32.26	39.37	5.81	.36	9,592

TABLE 4.—*Analyses and composition of coals—Continued.*

DRY COAL.

Test No.	Calculated proximate composition.				Heat value (B. t. u.)	Ultimate analysis. ^a					
	Volatile matter.	Fixed carbon.	Ash.	Sulphur.		Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.	Ash.
33.....	29.94	65.65	4.41	0.51	14,380	5.35	80.50	1.24	8.21	0.62	4.08
24.....	34.86	49.47	15.67	1.08	11,799	4.66	70.41	1.59	12.44	1.58	9.32
26.....	24.31	57.24	18.45	.58	12,524	4.48	72.83	1.07	6.46	.66	14.50
35.....	36.13	56.33	7.54	2.06	13,550	4.89	76.21	1.43	7.93	1.77	7.77
21.....	31.97	61.62	6.41	.44	14,234	5.01	79.73	1.22	7.56	.55	5.93
30.....	33.46	62.66	3.88	.46	14,665	.....	.....	.....	.....	.....	.....
34.....	34.91	59.19	5.90	1.08	13,730	5.13	75.56	1.35	8.79	1.41	7.76
22.....	32.14	52.42	15.44	.69	12,722	5.08	73.68	1.28	6.01	1.22	12.73
28.....	32.95	57.90	9.15	.92	13,703	.....	.....	.....	.....	.....	.....
18.....	33.46	60.00	6.54	1.14	14,301	5.24	79.00	1.38	6.72	1.14	6.52
19.....	33.70	58.60	7.70	1.46	14,123	.....	.....	.....	.....	.....	.....
20.....	33.94	59.24	6.82	1.52	14,247	.....	.....	.....	.....	.....	.....
32.....	33.51	61.49	5.00	.87	14,386	.....	.....	.....	.....	.....	.....
31.....	36.12	61.66	2.22	.74	14,706	5.00	78.14	1.67	8.30	1.83	5.06
25.....	21.05	63.31	5.64	1.55	14,720	5.09	82.46	1.42	4.95	.83	5.25
27.....	29.39	63.69	6.92	1.20	14,530	.....	.....	.....	.....	.....	.....
29.....	41.66	50.84	7.50	.46	12,386	5.03	68.80	1.08	17.58	.42	7.09

^a The ultimate analyses are mostly of the mine samples, and hence differ from analyses of test samples, especially in the percentages of ash. The composition of the coal free from moisture and ash probably does not differ much.

COMPOSITION OF COALS.

Test No.	Calculated proximate composition.			Heat value (B. t. u.)	Calculated ultimate composition.				
	Volatile matter.	Fixed carbon.	Sulphur.		Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.
33.....	31.32	68.68	0.53	15,043	5.58	83.92	1.29	8.56	0.65
24.....	41.34	58.66	1.28	13,991	5.14	77.65	1.75	13.72	1.74
26.....	28.81	70.19	.71	15,358	5.24	85.18	1.25	7.56	.77
35.....	39.07	60.93	2.23	14,656	5.30	82.63	7.55	8.60	1.92
21.....	34.16	65.84	.47	15,210	5.32	84.75	1.30	8.05	.58
30.....	34.81	65.19	.48	15,257	.....	.....	.....	.....	.....
34.....	37.10	62.90	1.15	14,591	5.56	81.91	1.46	9.54	1.53
22.....	38.01	61.99	.82	15,046	5.82	84.43	1.47	6.88	1.40
28.....	36.27	63.73	.79	15,082	.....	.....	.....	.....	.....
18.....	35.80	64.20	1.22	15,302	5.61	84.51	1.48	7.18	1.22
19.....	36.51	63.49	1.58	15,300	.....	.....	.....	.....	.....
20.....	36.42	63.58	1.63	15,289	.....	.....	.....	.....	.....
32.....	35.27	64.73	.92	15,192	.....	.....	.....	.....	.....
31.....	36.94	63.06	.76	15,039	5.27	82.30	1.76	8.74	1.93
25.....	32.91	67.09	1.64	15,601	5.37	87.03	1.50	5.22	.88
27.....	31.57	68.43	1.29	15,610	.....	.....	.....	.....	.....
29.....	45.04	54.96	.50	13,390	5.41	78.05	1.16	18.93	.45

TABLE 5—Retort operation, coal and coke.

Test No.	Coal.						Coke.				
	Coal No.	State.	Per cent re- jected by ¾-inch bar screen.	Screened, as charged (pounds).	Charged, dry (pounds).	Charged, ash and moist- ure free (pounds).	Yield (pounds).	Dry (per cent of coal charged).	Dry (per cent of dry coal charged).	Per cent of breaze through ¾- inch bar screen.	
33.....	A. A. 8...	Alabama.....	23.40	400	389	372	273	68.3	70.2	12.5	
24.....	A. A. 4...	Colorado.....	39.50	400	371	313	240	60.0	64.6	37.3	
26.....	A. A. 6...	do.....	13.83	410	403	329	307	74.9	76.0	10.0	
35.....	A. A. 12...	Illinois.....	27.90	400	381	353	249	62.3	65.4	6.7	
21.....	A. A. 3...	Kentucky.....	^a 30.80	360	351	329	250	69.4	71.3	.....	
30.....	do.....	do.....	48.50	400	388	372	258	64.5	66.5	9.1	
34.....	A. A. 9...	Michigan.....	9.70	400	363	341	238	59.5	65.6	17.9	
22.....	A. A. 2...	New Mexico.....	11.95	398	389	329	270	67.8	69.4	13.1	
28.....	A. A. 1...	do.....	21.90	400	391	355	280	70.0	71.0	11.7	
18.....	do.....	Pennsyl- vania.....	(b)	404	396	320	271	67.1	68.5	5.0	
19.....	do.....	do.....	(b)	400	391	370	270	67.5	69.0	.....	
20.....	do.....	do.....	(b)	400	392	365	259	64.8	66.1	.....	
32.....	do.....	do.....	17.40	400	390	370	274	68.5	70.3	7.6	
31.....	A. A. 10...	Tennessee.....	8.37	400	387	379	267	66.8	69.0	7.6	
25.....	A. A. 5...	West Vir- ginia.....	63.27	400	395	372	302	75.5	76.5	10.0	
27.....	do.....	do.....	70.00	400	394	368	285	71.2	72.4	7.6	
29.....	A. A. 7...	Wyoming.....	10.4	400	309	286	201	50.2	64.9	88.4	

Test No.	Products of destructive distillation.						Heat value of coke (B.t.u.).	Carbon-ization period (hours).	Retort temperature (°F.).		
	Coal No.	State.	Vola- tile mat- ter.	Fixed car- bon.	Ash.	Sul- phur.			On top of coal at center of retort.		Aver- age at ex- terior.
									After 1 hour.	Maxi- mum.	
33.....	A. A. 8...	Alabama.....	1.59	81.01	11.40	0.52	12,883	4.63	1,240	1,345	1,878
24.....	A. A. 4...	Colorado.....	1.78	72.87	25.35	.87	10,706	4.50	1,320	1,700	2,036
26.....	A. A. 6...	do.....	.95	78.39	20.66	.49	11,700	4.42	1,430	1,820	2,123
35.....	A. A. 12...	Illinois.....	2.22	85.48	12.30	2.08	12,427	4.67	1,220	1,360	1,779
21.....	A. A. 3...	Kentucky.....	1.05	87.43	11.52	.41	12,802	4.42	1,470	1,740	2,036
30.....	do.....	do.....	.39	89.60	10.01	.43	13,003	4.50	1,340	1,550	2,020
34.....	A. A. 9...	Michigan.....	2.20	92.01	5.79	.91	13,495	4.75	1,090	1,140	1,828
22.....	A. A. 2...	New Mexico.....	.75	76.65	22.60	.40	11,173	4.48	1,390	1,690	.....
28.....	A. A. 1...	do.....	2.75	79.69	17.56	.54	11,781	4.42	.....	1,748	1,962
18.....	do.....	Pennsyl- vania.....	1.06	86.41	12.53	.92	12,631	4.48	.....	1,770	1,982
19.....	do.....	do.....	1.49	87.50	11.01	.84	12,893	4.83	1,350	1,690	.....
20.....	do.....	do.....	.89	87.77	11.34	1.11	12,782	4.55	1,460	1,755	2,010
32.....	do.....	do.....	1.85	89.45	8.70	.74	13,086	4.85	1,310	1,400	1,844
31.....	A. A. 10...	Tennessee.....	1.17	92.75	6.08	.70	13,790	4.67	1,310	1,465	1,938
25.....	A. A. 5...	West Vir- ginia.....	.49	87.41	12.10	.85	12,731	4.52	1,397	1,710	2,042
27.....	do.....	do.....	.73	86.01	13.26	1.19	12,591	4.50	1,230	1,725	2,101
29.....	A. A. 7...	Wyoming.....	1.27	85.01	13.72	.41	12,474	4.25	.....	.....	.....

^a A ¾-inch bar screen was used in this test.^b The coal in these tests had been passed over a ¾-inch bar screen at the mine and was not screened again.

TABLE 6.—*Yield, heating value, and candlepower of gas.*

Test No.	Yield of gas per pound of coal (cubic feet).			Calculated average heating value (B. t. u.).		Calculated average candlepower.	Calculated average gas analysis (per cent).						
	Coal as charged.	Dry coal.	Coal ash and moisture (free).	Gross.	Net.		CO ₂ .	CnH ₂ n.	O ₂ .	CO.	CH ₄ .	H ₂ .	N ₂ .
33.	5.2	5.3	5.6	598	538	14.0	2.7	3.7	1.0	8.9	31.2	49.1	3.4
24.	4.8	5.2	6.1	<i>a</i> 626	<i>a</i> 566	<i>a</i> 14.0	<i>a</i> 4.4	<i>a</i> 5.3	<i>a</i> 0.8	<i>a</i> 11.3	<i>a</i> 29.8	<i>a</i> 43.9	<i>a</i> 4.5
26.	4.9	5.0	6.1	614	550	<i>a</i> 12.0	1.3	<i>a</i> 4.2	0.9	6.0	29.5	55.8	2.3
35.	4.3	4.6	4.9	<i>a</i> 632	<i>a</i> 568	15.2	2.5	3.7	0.8	7.9	33.5	45.6	6.0
21.	4.8	4.9	5.3	650	578	14.5	<i>a</i> 1.6	<i>a</i> 4.3	<i>a</i> 1.1	<i>a</i> 6.4	<i>a</i> 33.1	<i>a</i> 50.3	<i>a</i> 3.2
30.	5.0	5.2	5.4	622	561	14.1	1.9	4.1	0.7	7.0	29.4	51.3	5.6
34.	4.3	4.7	5.0	593	526	17.4	<i>a</i> 2.9	<i>a</i> 5.3	<i>a</i> 0.7	<i>a</i> 9.2	<i>a</i> 34.1	<i>a</i> 43.1	<i>a</i> 4.7
22.	4.5	4.7	5.5	674	606	<i>a</i> 16.5	2.0	<i>a</i> 5.9	0.8	8.2	<i>a</i> 34.8	<i>a</i> 45.9	2.4
28.	4.9	5.0	5.5	682	618	16.8	2.1	6.1	0.6	8.2	35.5	45.7	1.8
18.	4.8	4.9	6.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
19.	4.9	5.0	5.3	649	593	<i>a</i> 15.2	1.2	4.4	1.1	6.6	<i>a</i> 37.9	<i>a</i> 42.2	6.6
20.	5.3	5.4	5.8	611	550	16.0	1.1	3.0	0.8	6.5	31.8	51.6	5.2
32.	5.1	5.3	5.6	<i>a</i> 664	<i>a</i> 603	<i>a</i> 15.4	<i>a</i> 1.7	<i>a</i> 3.8	<i>a</i> 0.5	<i>a</i> 6.5	<i>a</i> 33.6	<i>a</i> 50.7	<i>a</i> 3.2
31.	5.5	5.7	5.8	641	575	15.9	2.0	5.0	0.9	8.2	31.2	49.1	3.6
25.	5.2	5.3	5.6	617	555	<i>a</i> 15.8	1.3	3.8	0.9	4.9	<i>a</i> 32.9	<i>a</i> 53.6	2.6
27.	5.0	5.1	5.4	622	557	<i>a</i> 16.1	1.2	3.3	0.6	5.0	32.6	55.1	1.8
29.	5.4	7.0	7.5	<i>b</i> 564	<i>b</i> 502	8.8	<i>b</i> 7.6	<i>b</i> 4.9	<i>b</i> 0.2	<i>b</i> 14.4	<i>b</i> 29.0	<i>b</i> 40.2	<i>b</i> 3.7

a One figure of the nine used in obtaining the average was supplied by interpolation.*b* From the proportional tank; no half-hour samples were taken on this test.TABLE 7.—*Yield of tar, ammonia, sulphur, and naphthalene.*

Test No.	Tar per ton of coal (gallons).			Ammonia (NH ₃) per ton of coal (pounds).			H ₂ S per 100 cubic feet of gas at outlet of scrubber (grains).	Total naphthalene per ton of coal as charged (pounds).
	Coal as charged.	Dry coal.	Coal ash and moisture free.	Coal as charged.	Dry coal.	Coal ash and moisture free.		
33.	19.2	19.7	20.6	4.03	4.15	4.33	.....	10.7
24.	15.6	16.8	19.9	7.60	8.20	9.60	.....	.....
26.	14.2	14.5	17.7	4.36	4.43	5.43	.....	.....
35.	17.2	18.1	19.5	6.38	6.70	7.20	1,390	4.5
21.	10.8	11.1	11.8	4.01	4.12	4.39	.....	.....
30.	18.8	19.5	20.2	3.48	3.61	4.25	823	5.7
34.	16.5	18.2	19.3	<i>a</i> 6.40	<i>a</i> 7.05	<i>a</i> 7.50	3,750	5.5
22.	16.8	17.2	20.3	<i>a</i> 4.97	<i>a</i> 5.09	<i>a</i> 6.02	.....	.....
28.	21.8	22.3	24.5	4.32	4.42	4.82	.....	.....
18. ....	.....	.....	.....	.....	.....	.....	.....	.....
19.	10.7	10.9	11.8	5.80	5.93	6.43	.....	.....
20. ....	.....	.....	.....	5.18	5.28	5.67	.....	.....
32.	21.1	21.6	22.8	5.33	5.46	5.75	830	8.0
31.	22.0	22.7	23.2	<i>a</i> 7.39	<i>a</i> 7.63	<i>a</i> 7.81	296	.....
25.	20.1	20.4	21.7	5.19	5.26	5.57	.....	.....
27.	14.6	14.8	15.9	4.37	4.43	4.75	.....	11.4
29.	14.4	18.6	20.1	3.77	4.88	5.28	1,660	.....

a One figure of the nine used in obtaining the average was supplied by interpolation.

TABLE 8.—Results of tests on eleven coals from various States.

Source.	Coal A. A. No.	Test No.	Retort temperatures (°F.).			Average temperatures of condensing system (°F.).					Gas leaving station meter.
			Interior.		Exterior, average.	Condenser.			Tar extractor.		
			After 1 hour.	Maxi- mum.		No. 1.	No. 2.	No. 3.	Inlet.	Outlet.	
Scott Haven, Pa.	1	18	.....	1,770	1,994	160	143	133	116	105	53
		19	1,350	1,690	2,010	127	134	125	107	100	61
		20	1,460	1,755	2,010	151	138	129	105	100	60
	8	32	1,310	1,400	1,844	136	129	111	104	93	53
		33	1,240	1,345	1,878	144	145	125	106	103	61
		34	1,320	1,700	2,036	157	144	125	109	105	58
	4	24	1,430	1,820	2,123	110	107	104	98	86	57
		26	1,220	1,360	1,779	162	146	121	110	105	56
		35	1,470	1,740	2,036	138	120	116	100	93	56
	3	21	1,340	1,550	2,030	137	122	117	109	93	70
30		1,600	1,140	1,828	174	154	138	127	124	48	
34		1,390	1,690	1,962	129	128	116	106	99	61	
9	22	.....	1,748	1,932	125	116	112	104	97	77	
	28	1,310	1,465	1,938	138	137	114	106	95	63	
	31	1,397	1,710	2,042	112	134	105	95	81	58	
10	25	1,230	1,725	2,101	116	124	114	104	92	59	
	5	27	.....	.....	.....	.....	.....	.....	.....	52	
	7	29	.....	.....	.....	.....	.....	.....	.....	54	

TABLE 8.—Results of individual tests, etc.—Continued.

Source.	Coal A. A. No.	Test No.	Coke (per cent of coal charged).	Per pound of coal charged (cubic feet, cor- rected).	Average candle- power (approx- imate).	Candle- feet per pound of coal.	Average heat- ing value per cubic foot (B. t. u.).		Heating value per pound of coal (B. t. u.).	Gas.						Hydro- gen.	Nitro- gen.	
							Gross.	Net.		Carbon dioxide.	Illumi- nants.	Oxygen.	Carbon monox- ide.	Methane.				
Scott Haven, Pa.	1	18	67.1	4.84	15.2	75.00	649	593	3,200	1.2	4.4	1.1	0.6	37.9			42.2	6.6
		19	67.5	4.93	16.0	84.30	611	550	3,230	1.1	3.0	.8	0.5	31.8			51.6	5.2
		20	64.8	5.27	15.4	79.20	604	603	3,410	1.7	3.8	.5	0.5	33.6			50.1	3.2
		32	68.5	5.14	14.0	72.50	598	538	3,100	2.7	3.7	1.0	8.9	31.2			49.1	3.4
		33	68.3	5.18	14.0	67.20	626	566	3,010	4.4	5.3	1.8	11.3	29.8			43.9	2.3
		24	59.9	4.81	12.0	58.80	614	550	3,008	1.3	4.2	.9	6.0	29.5			55.8	6.0
		6	75.0	4.90	15.2	65.30	632	568	2,718	2.5	3.7	.8	7.9	33.5			45.6	3.2
		35	62.3	4.30	14.5	69.75	650	578	3,126	1.6	4.3	1.1	6.4	33.1			50.3	5.6
		21	69.4	4.81	14.1	70.50	622	561	3,110	1.9	4.1	.7	7.0	29.4			51.3	4.7
		3	64.5	5.00	14.1	74.80	593	526	2,550	2.9	5.3	.7	9.2	34.1			43.1	2.4
		9	59.5	4.30	17.4	74.30	674	606	3,033	2.0	5.9	1.6	8.2	35.5			45.7	1.8
		2	67.8	4.50	16.5	82.30	682	618	3,342	2.1	6.1	.6	8.2	31.2			49.1	3.6
Van Houten, N. Mex.	2	28	70.0	4.90	16.8	81.90	641	575	3,525	2.0	5.0	.9	9.9	32.9			51.6	2.6
		31	66.8	5.50	15.9	82.20	617	555	3,208	1.3	3.8	.8	4.9	32.6			53.5	1.8
		25	75.5	5.20	15.8	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		27	71.3	5.00	16.1	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		29	50.2	5.40	8.8	47.50	504	502	3,046	7.6	4.9	.2	14.4	29.0			40.2	3.7
Blotton, Ala.	8	33	68.3	5.18	14.0	67.20	626	566	3,010	4.4	5.3	1.8	11.3	29.8			43.9	2.3
		24	59.9	4.81	12.0	58.80	614	550	3,008	1.3	4.2	.9	6.0	29.5			55.8	6.0
		6	75.0	4.90	15.2	65.30	632	568	2,718	2.5	3.7	.8	7.9	33.5			45.6	3.2
Oak Creek, Colo.	4	26	75.0	4.90	15.2	65.30	632	568	2,718	2.5	3.7	.8	7.9	33.5			45.6	3.2
		27	62.3	4.30	14.5	69.75	650	578	3,126	1.6	4.3	1.1	6.4	33.1			50.3	5.6
		35	62.3	4.81	14.1	70.50	622	561	3,110	1.9	4.1	.7	7.0	29.4			51.3	4.7
Sopris, Colo.	6	21	69.4	4.81	14.1	70.50	622	561	3,110	1.9	4.1	.7	7.0	29.4			51.3	4.7
		3	64.5	5.00	14.1	74.80	593	526	2,550	2.9	5.3	.7	9.2	34.1			43.1	2.4
		9	59.5	4.30	17.4	74.30	674	606	3,033	2.0	5.9	1.6	8.2	35.5			45.7	1.8
Harrisburg, Ill.	12	22	67.8	4.50	16.5	82.30	682	618	3,342	2.1	6.1	.6	8.2	31.2			49.1	3.6
		28	70.0	4.90	16.8	81.90	641	575	3,525	2.0	5.0	.9	9.9	32.9			51.6	2.6
		31	66.8	5.50	15.9	82.20	617	555	3,208	1.3	3.8	.8	4.9	32.6			53.5	1.8
Hellier, Ky.	3	27	71.3	5.00	16.1	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		25	75.5	5.20	15.8	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		29	50.2	5.40	8.8	47.50	504	502	3,046	7.6	4.9	.2	14.4	29.0			40.2	3.7
Saginaw, Mich.	9	33	68.3	5.18	14.0	67.20	626	566	3,010	4.4	5.3	1.8	11.3	29.8			43.9	2.3
		24	59.9	4.81	12.0	58.80	614	550	3,008	1.3	4.2	.9	6.0	29.5			55.8	6.0
		6	75.0	4.90	15.2	65.30	632	568	2,718	2.5	3.7	.8	7.9	33.5			45.6	3.2
Van Houten, N. Mex.	2	22	67.8	4.50	16.5	82.30	682	618	3,342	2.1	6.1	.6	8.2	31.2			49.1	3.6
		28	70.0	4.90	16.8	81.90	641	575	3,525	2.0	5.0	.9	9.9	32.9			51.6	2.6
		31	66.8	5.50	15.9	82.20	617	555	3,208	1.3	3.8	.8	4.9	32.6			53.5	1.8
La Follette, Tenn.	10	25	75.5	5.20	15.8	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		27	71.3	5.00	16.1	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		29	50.2	5.40	8.8	47.50	504	502	3,046	7.6	4.9	.2	14.4	29.0			40.2	3.7
Page, W. Va.	5	27	71.3	5.00	16.1	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		25	75.5	5.20	15.8	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		29	50.2	5.40	8.8	47.50	504	502	3,046	7.6	4.9	.2	14.4	29.0			40.2	3.7
Hanna, Wyo.	7	29	50.2	5.40	8.8	47.50	504	502	3,046	7.6	4.9	.2	14.4	29.0			40.2	3.7
		27	71.3	5.00	16.1	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8
		25	75.5	5.20	15.8	80.50	622	557	3,110	1.2	3.3	.6	3.0	32.6			53.5	1.8

a One figure from the nine used in obtaining average was supplied by interpolation from the curves.

MANNER OF RECORDING AND COMPUTING DATA.

GENERAL STATEMENT.

The purpose of this bulletin is twofold—to present data obtained in tests made on a scale that would give results comparable with those of ordinary practice, and to show the methods used in an illuminating-gas experiment station that embodies the conclusions reached after much study and many trials.

In furtherance of both these purposes, specimens of the record sheets, forms for computing, and computation sheets used at the plant are reproduced herewith. The record and computation sheets are filled out for Test 35. They show all the data recorded and the methods used in getting the results stated in Tables 3 to 8 and platted in Plate IV. By going over them the reader can determine for himself the reliability of the general plan followed. The chief reasons for inserting the sheets, however, is that they may be of aid to any engineer who is preparing to make or is carrying on distillation tests of gas coals, by serving as guides in the preparation of forms and record blanks that will meet his needs.

SHEETS FOR RECORDING TESTS.

SHEET A 1.

Test No. 35.

COAL AND COKE.

Date: May 28, 1909.

Observer: D. F. Smith.

Coal:		Coke:	
Time of charging.....	12.40 p. m.	Time of drawing.....	5.20 p. m.
Weight of car and coal.....	————	Weight of buggy and coke,	
Weight of car.....	Balanced.	pounds.....	636
Weight of coal charged... pounds..	400	Weight of buggy..... pounds..	387
Kind of coal.....	————	Weight of coke..... do....	249
Coal No.....	A. A. 12	Coke produced..... per cent..	62.3
Company.....	————	Physical characteristics..	Dark color; easily broken.
Mine location.....	Harrisburg, Saline County, Ill.	Analysis, before quenching:	
Analysis, as charged:		Moisture.....	————
Moisture.....	4.66	Ash.....	12.30
Ash.....	7.19	Volatile matter.....	2.22
Volatile matter.....	34.44	Fixed carbon.....	85.48
Fixed carbon.....	53.71	Sulphur, separately determined....	2.08
Sulphur, separately determined....	1.96	Heating value..... B. t. u..	12,427
Heating value..... B. t. u..	12,919	Remarks:	
Remarks:		Retort badly covered on top with	
Retort badly covered on top with		carbon, temperature low.	

*Sheets for recording tests—Continued.*SHEET A 2.
Test No. 35.Date: May 28, 1909.
Observer: Wynne.**RETORT TEMPERATURE.**

Time of taking sample.	Distance from rear.	Temperature inside retort (° F.).			Time of taking sample.	Temperature outside retort (° F.).		
		At terminals.	Observed.	Corrected.		Distance from retort.	Observed.	Corrected.
<i>p. m.</i>					<i>p. m.</i>			
12.50.....	4 feet 6 inches.....		1,050	1,095	12.50.....	1½ inches.....	1,765	1,790
1.00.....	do.....		1,115	1,150	1.00.....	do.....	1,775	1,800
1.10.....	do.....		1,140	1,175	1.10.....	do.....	1,785	1,810
1.20.....	do.....		1,150	1,185	1.20.....	do.....	1,750	1,775
1.30.....	do.....		1,160	1,190	1.30.....	do.....	1,760	1,780
1.40.....	do.....		1,175	1,200	1.40.....	do.....	1,760	1,780
1.50.....	do.....		1,190	1,220	1.50.....	do.....	1,740	1,760
2.00.....	do.....		1,205	1,230	2.00.....	do.....	1,740	1,760
2.10.....	do.....		1,215	1,240	2.10.....	do.....	1,745	1,765
2.20.....	do.....		1,230	1,250	2.20.....	do.....	1,745	1,765
2.30.....	do.....		1,240	1,260	2.30.....	do.....	1,750	1,775
2.40.....	do.....		1,265	1,285	2.40.....	do.....	1,760	1,780
2.50.....	do.....		1,270	1,290	2.50.....	do.....	1,765	1,790
3.00.....	do.....		1,295	1,310	3.00.....	do.....	1,760	1,780
3.10.....	do.....		1,325	1,340	3.10.....	do.....	1,755	1,780
3.20.....	do.....		1,335	1,350	3.20.....	do.....	1,770	1,795
3.30.....	do.....		1,335	1,350	3.30.....	do.....	1,770	1,795
3.40.....	do.....		1,345	1,355	3.40.....	do.....	1,765	1,790
3.50.....	do.....		1,350	1,360	3.50.....	do.....	1,750	1,775
4.00.....	do.....		1,345	1,355	4.00.....	do.....	1,745	1,765
4.10.....	do.....		1,340	1,350	4.10.....	do.....	1,740	1,760
4.20.....	do.....		1,335	1,350	4.20.....	do.....	1,745	1,765
4.40.....	do.....		1,325	1,340			1,750	1,775
5.00.....	do.....		1,325	1,340			1,750	1,775
						Av.....		1,779

SHEET A 3.
Test No. 35.Date: May 29, 1909.
Observer: D. F. Smith.**GENERAL TEMPERATURE.**

Time of taking sample.	Condenser temperatures.			Separator temperatures.		Meter temperatures.		Purifier.
	1	2	3	Inlet.	Outlet.	Water.	Outlet.	
<i>p. m.</i>								
12.50.....	178	192	180	166	124	70	69	.....
1.00.....	178	182	170	162	136	70	69	.....
1.10.....	180	170	158	150	132	70	69	.....
1.20.....	176	170	150	138	126	70	69	.....
1.30.....	174	168	140	128	119	70	69	.....
1.40.....	170	158	130	119	118	71	70	.....
1.50.....	160	153	118	110	110	71	69	.....
2.00.....	160	144	115	105	107	71	69	.....
2.10.....				100	103	71	69	.....
2.20.....				98	100	71	69	.....
2.30.....	150	140	105	98	100	71	69	.....
2.40.....				101	100	71	69	.....
2.50.....				104	100	71	69	.....
3.00.....	140	138	118	106	102	71	69	.....
3.10.....				107	100	71	69	.....
3.20.....				107	100	71	69	.....
3.30.....	130	130	110	106	100	71	69	.....
3.40.....				105	100	72	69	.....
3.50.....				102	98	72	70	.....
4.00.....	120	134	112	102	98	72	70	.....
4.10.....				100	95	72	70	.....
4.20.....				96	94	72	70	.....
4.30.....	118	140	115	92	93	72	70	.....
4.40.....				92	93	72	70	.....
4.50.....	110	142	100	90	92	72	70	.....
5.00.....				88	91	72	70	.....
Corrected average.....	162	146	121	110	105	72	70	.....

Sheets for recording tests—Continued.

SHEET A 4.
Test No. 35.Date: May 28, 1909.
Observer: D. F. Smith.

PRESSURES.

Time of taking sample.	Stand- pipe (inches).	Separator inlet (inches).	Separator differ- ence (inches).	Washer differ- ence (inches).	Meter (inches).	Meter reading.	
						Total. (cu. ft.).	Period. (cu. ft.).
<i>p. m.</i>							
12.40	0.1					00	
12.45						30	30
12.50	0.1	0.2	2.1	3.8	4.9	64	34
12.55	0.1	0.1	2.0	3.8	4.8	95	31
1.00						124	29
1.05	0.1	0.2	1.8	3.8	4.9	154	30
1.10	0.0	-0.1	1.9	3.8	4.7	185	31
1.15	-0.1	-0.1	1.9	3.8	4.7	216	31
1.20	0.2	0.2	1.9	3.8	4.5	248	32
1.25	0.0	0.0	1.9	3.6	4.7	279	31
1.30	0.1	0.1	1.9	3.2	4.7	313	34
1.35	0.3	0.3	1.9	3.0	4.8	346	33
1.40	0.0	0.1	1.9	3.0	5.0	380	34
1.45	0.0	0.0	1.8	3.0	5.0	414	34
1.50	0.0	0.0	1.8	3.0	5.0	448	34
1.55	-0.1	-0.1	1.8	3.0	5.0	482	34
2.00	0.0	0.0	1.7	3.0	5.0	518	36
2.05	0.2	0.2	1.7	3.0	5.0	553	35
2.10	0.1	0.1	1.7	3.0	5.0	590	37
2.15	0.2	0.2	1.7	3.0	5.0	627	37
2.20	0.2	0.2	1.7	3.0	5.0	660	33
2.25	0.1	0.1	1.7	3.0	5.0	702	42
2.30	-0.1	-0.1	1.7	3.0	5.0	740	38
2.35	-0.1	-0.1	1.7	3.0	5.0	779	39
2.40	0.0	0.0	1.7	3.0	5.0	818	39
2.45	0.0	0.0	1.7	3.1	5.0	858	40
2.50	0.1	0.1	1.7	3.0	5.0	899	41
2.55	0.1	0.1	2.0	3.0	5.0	939	40
3.00	0.1	0.1	1.9	3.0	5.0	980	41
3.05	0.0	-0.1	1.8	3.0	5.0	1,021	41
3.15	0.0	0.0	1.9	3.0	5.0	1,103	82
3.20	0.1	0.1	1.9	3.0	5.0	1,144	41
3.25	-0.1	-0.1	2.0	3.0	5.0	1,184	40
3.30	-0.1	-0.1	1.9	3.0	5.0	1,226	42
3.35	-0.1	-0.1	1.8	3.0	5.0	1,267	41
3.40	0.0	0.0	1.7	3.0	5.0	1,308	41
3.45	0.1	0.0	1.7	3.0	5.0	1,348	40
3.50	-0.1	-0.1	1.8	3.0	5.0	1,385	37
3.55	0.0	-0.1	1.8	2.9	5.0	1,428	43
4.00	0.0	0.0	1.8	3.0	5.0	1,466	38
4.05	0.1	0.1	1.7	3.0	5.0	1,503	37
4.10	0.1	0.1	1.7	3.0	5.0	1,540	37
4.15	0.1	0.1	1.7	3.0	5.0	1,573	33
4.20	0.0	-0.1	1.6	3.0	5.1	1,605	32
4.25	0.0	-0.2	1.6	3.0	5.0	1,636	31
4.30	0.1	0.1	1.5	3.0	5.0	1,665	29
4.35	0.1	0.0	1.5	3.0	5.0	1,691	26
4.45	0.1	0.1	1.5	3.0	5.0	1,740	49
4.50	0.1	0.1	0.8	3.0	5.0	1,760	20
4.55	0.0	0.0	0.8	3.0	5.0	1,776	16
5.00	0.0	0.0	0.7	3.0	5.0	1,788	12
5.05	0.0	0.0	0.5	3.0	5.0	1,799	11
5.10						1,807	8
						1,814	7

Sheets for recording tests—Continued.

SHEET A 5.
Test No. 35.Date: May 28, 1909.
Observer: Wynne.

CALORIMETER.

Time of taking sample.	Water inlet—temperature (°C.).						Water outlet—temperature (°C.).					
	1	2	3	4	5	Average.	1	2	3	4	5	Average.
<i>p. m.</i>												
12.45 to 1.15.....	16.1	16.1	16.1	16.1	16.1	16.1	42.0	41.9	41.9	42.0	42.1	41.98
1.15 to 1.45.....	15.4	15.4	15.4	15.4	15.4	15.4	42.9	43.0	43.2	43.3	43.5	43.18
1.45 to 2.15.....	15.6	15.6	15.7	15.7	15.7	15.66	41.9	41.9	42.0	42.1	42.2	42.02
2.15 to 2.45.....	16.0	16.0	16.0	16.1	16.1	16.04	45.1	45.1	45.1	45.0	45.1	45.08
2.45 to 3.15.....	15.9	16.0	16.0	16.0	16.1	16.0	46.5	46.6	46.7	46.8	46.9	46.6
3.15 to 3.45.....	16.1	16.2	16.2	16.1	16.1	16.14	47.0	47.0	47.0	47.1	47.2	47.06
3.45 to 4.15.....	16.5	16.5	16.5	16.5	16.5	16.5	45.5	45.5	45.6	45.6	45.7	45.58
4.15 to 4.45.....	16.0	16.0	16.1	16.1	16.1	16.04	43.4	43.5	43.5	43.6	43.6	43.52
4.45 to 5.15.....	18.5	18.5	18.6	18.6	18.6	18.56	44.4	44.5	44.6	44.7	44.8	44.60
Proportional tank.....	17.9	18.0	18.0	18.1	18.1	18.02	46.6	46.7	47.0	47.0	47.0	46.86
	18.1	18.1	18.1	18.0	18.0	18.06	46.6	46.6	46.6	46.6	46.6	46.6

SHEET A 5.
Test No. 35.Date: May 28, 1909.
Observer: Wynne.

Time of taking sample.	Meter reading (cubic feet).			Weight of water (grams).	Condensed water (grams).	Gas temperature (°F.).	Barometer (inches).	Corrected gas (cubic feet).	B. t. u. per cubic foot.	
	Start.	Close.	Used.						Gross.	Net.
<i>p. m.</i>										
12.45 to 1.15.....	53.00	53.25	0.25	1,523	5.3	75	29.3	0.234	670	616
1.15 to 1.45.....	54.60	54.85	.25	1,646	6.8	75	29.3	.234	775	706
1.45 to 2.15.....	56.00	56.25	.25	1,555	7.0	75	29.3	.234	695	624
2.15 to 2.45.....	59.40	59.65	.25	1,373	6.5	75	29.3	.234	676	610
2.45 to 3.15.....	61.90	62.15	.25	1,200	7.0	75	29.3	.234	626	555
	62.40	62.65	.25	1,190	7.0	76	29.3	.234	625	554
3.15 to 3.45.....	64.70	64.95	.25	1,177	5.8	76	29.3	.234	582	524
3.45 to 4.15.....	66.90	67.15	.25	1,100	6.0	76	29.3	.234	513	452
4.15 to 4.45.....	69.50	69.75	.25	1,025	5.0	77	29.3	.233	455	404
4.45 to 5.15.....	73.00	73.25	.25	975	5.0	78	29.3	.232	402	351
Proportional tank.....	74.4	74.65	.25	1,300	7.0	79	29.3	.232	641	569
	75.0	75.25	.25	1,360	7.0	80	29.3	.231	666	594
Calculated average.....									654	582

SHEET A 6a.
Test No. 35.Date: May 28, 1909.
Observer: W. T. Alliger.

PHOTOMETER.

Time of taking sample.	Time burning (minutes).			Meter reading.			Gas per hour measured (cubic feet).	Gas temperature (°F.).	Gas per hour corrected (cubic feet).	Tabular No.	Candle-power.
	Start.	Close.	Length.	Start.	Close.	Used.					
<i>p. m.</i>											
12.40 to 1.10.....	0	5	5	45.0	12.7	17.7	3.54	80	3.26	7426	22.7
1.10 to 1.40.....	0	5	5	2.5	22.6	20.1	4.02	82	3.69	7791	21.1
1.40 to 2.10.....	0	5	5	2.0	24.9	22.9	4.58	82	4.21	7791	18.5
2.10 to 2.40.....	0	5	5	10.0	34.9	24.9	4.98	82	4.58	8162	17.85
2.40 to 3.10.....	0	5	5	25.0	32.5	27.5	5.50	82	5.05	7914	15.7
3.10 to 3.40.....	0	5	5	.0	28.0	28.0	5.60	82	5.15	7669	14.9
3.40 to 4.10.....	0	5	5	23.0	51.4	28.4	5.68	83	5.20	5795	11.1
4.10 to 4.40.....	0	5	5	40.0	20.7	30.7	6.14	83	5.61	.....	9.62
4.40 to 5.10.....	0	5	5	40.0	19.6	29.6	5.92	84	5.40	.....	5.12
Proportional.....	0	5	5	35.0	11.1	26.1	5.22	85	4.74	8037	16.9
	0	5	5	15.0	41.1	26.1	5.22	85	4.74	8037	16.9

Sheets for recording tests—Continued.

SHEET A 6b.
Test No. 35.Date: May 28, 1909.
Observer: W. T. Alliger.

PHOTOMETER—Continued.

[Average barometer, 29.3.]

Time of taking sample.	Photometer readings (mm.).										
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Average.
<i>p. m.</i>											
12.40 to 1.10	492	490	485	490	490	489	488	490	489	492	489
1.10 to 1.40	484	487	484	486	484	478	470	477	478	472	480
1.40 to 2.10	489	485	483	483	480	480	477	473	473	474	480
2.10 to 2.40	475	473	470	470	470	470	472	470	469	469	471
2.40 to 3.10	481	483	481	474	473	482	478	472	476	473	477
3.10 to 3.40	490	486	486	486	486	484	475	480	478	477	483
3.40 to 4.10	539	541	538	538	539	537	540	541	545	542	540
4.10 to 4.40	662	663	660	656	652	655	649	642	665	660	656
4.40 to 5.10	1,116	1,117	1,123	1,135	1,128	1,141	1,163	1,154	1,164	1,164	1 140
Proportional.....	{ 482 471	{ 478 472	{ 480 471	{ 481 468	{ 477 469	{ 469 476	{ 468 477	{ 470 478	{ 468 476	{ 469 478	{ 474 474

SHEET A 7a.
Test No. 35.Date: May 28, 1909.
Observer: W. A. Dunkley.

GAS ANALYSIS.

Time of taking sample.	Volume of gas (c. c.).	CO.		CH ₄ .		O ₂ .		CO.	
		After KOH (c. c.).	Per cent.	After Br. (c. c.).	Per cent.	After P. (c. c.).	Per cent.	After Cu ₂ Cl ₂ (c. c.).	Per cent.
<i>p. m.</i>									
12.45 to 1.15	100.0	96.8	3.2	88.4	8.4	87.8	0.6	79.1	8.7
1.15 to 1.45	100.0	96.3	3.7	88.7	7.6	88.0	.7	80.1	7.9
1.45 to 2.15	99.5	96.4	3.1	90.6	5.8	90.0	.6	81.0	9.0
2.15 to 2.45	100.0	96.8	3.2	92.0	4.8	91.2	.8	82.8	8.4
2.45 to 3.15	100.0	97.4	2.6	94.6	2.8	93.8	.8	85.4	8.4
3.15 to 3.45	99.7	97.6	2.1	95.7	1.9	94.6	1.1	87.0	7.6
3.45 to 4.15	100.0	98.4	1.6	97.5	.9	96.7	.8	89.2	7.5
4.15 to 4.45	99.6	98.4	1.2	98.4	.0	98.0	.4	91.5	6.5
4.45 to 5.15	100.0	99.0	1.0	98.8	.2	96.5	2.3	91.6	4.9
Proportional.....	99.4	96.2	3.2	92.0	4.2	90.8	1.2	83.0	7.8

SHEET A 7b.
Test No. 35.Date: May 28, 1909.
Observer: W. A. Dunkley.

Time of taking sample.	After CuCl (c. c.).	Volume for explosion (c. c.).	Air to (c. c.).	Volume after explosion (c. c.).	Contraction (c. c.).	Volume after absorption (c. c.).	Absorption (c. c.).	CH ₄ (per cent.).	H ₂ (per cent.).	N ₂ (per cent.).
<i>p. m.</i>										
12.45 to 1.15	{ 79.1 80.1	{ 8.0 8.0	{ 99.3 99.0	{ 85.4 85.6	{ 13.9 14.0	{ 79.9 80.2	{ 5.5 5.4	{ 54.4 53.4	{ 19.1 21.2	{ 5.1
1.15 to 1.45	{ 80.1 81.0	{ 8.0 8.0	{ 99.4 99.5	{ 86.1 86.0	{ 13.3 13.5	{ 81.5 82.0	{ 4.6 4.0	{ 46.1 40.5	{ 26.7 27.3	{ 7.0
1.45 to 2.15	{ 81.0 82.8	{ 8.0 8.0	{ 99.4 98.8	{ 85.9 85.8	{ 13.5 13.0	{ 81.9 82.1	{ 4.0 3.7	{ 40.5 38.3	{ 37.1 38.6	{ 3.9
2.15 to 2.45	{ 82.8 85.4	{ 8.0 9.0	{ 98.8 99.6	{ 85.1 84.6	{ 12.8 15.0	{ 81.6 81.0	{ 3.7 3.6	{ 38.3 34.2	{ 40.0 49.3	{ 6.3
2.45 to 3.15	{ 85.4 87.0	{ 9.0 9.0	{ 99.3 99.1	{ 84.5 85.1	{ 14.8 14.0	{ 80.8 82.0	{ 3.7 3.1	{ 35.1 30.1	{ 46.8 50.2	{ 2.7
3.15 to 3.45	{ 87.0 89.2	{ 9.0 9.0	{ 98.8 99.0	{ 84.9 85.2	{ 13.9 13.7	{ 81.7 83.1	{ 3.2 2.3	{ 30.9 22.8	{ 48.4 60.1	{ 7.5
3.45 to 4.15	{ 89.2 91.5	{ 9.0 10.0	{ 99.0 98.7	{ 85.4 83.6	{ 15.1 15.8	{ 82.0 82.4	{ 1.6 1.7	{ 14.7 15.6	{ 73.0 72.4	{ 4.1
4.15 to 4.45	{ 91.5 91.6	{ 10.0 10.0	{ 99.3 99.0	{ 84.1 86.4	{ 15.2 12.7	{ 82.4 85.9	{ 1.7 .7	{ 15.6 6.4	{ 69.0 68.5	{ 16.5
4.45 to 5.15	{ 91.6	{ 10.0 10.0	{ 99.3 99.0	{ 86.6 86.4	{ 12.7 12.6	{ 85.9 85.7	{ .7 .7	{ 6.4 6.4	{ 69.0 68.5	{ 16.5
Proportional.....	{ 83.0	{ 8.0 8.0	{ 99.0 99.2	{ 86.2 86.6	{ 12.8 12.6	{ 83.0 83.4	{ 3.2 3.2	{ 33.1 33.1	{ 44.3 42.7	{ 7.0

Sheets for recording tests—Continued.

SHEET A 8a.

Test No. 35.

Date: May 28, 1909.

Observers: W. A. Dunkley, D. F. Smith.

TAR.

Time of taking sample.	Source.	Weight.				Volume.			
		Gross (gms.).	Tare (gms.).	Net (gms.).	Net (lbs.).	Jar.		Tar.	
						Total (c. c.).	Excess (c. c.).	c. c.	Gals.
<i>p. m.</i>									
12.40 to 1.10.....	Condenser.....	1,421	708	713	1,567	1,720	1,100	620	0.164
	do.....	1,580	621	959	2,110	1,800	970	830	.220
	do.....	1,370	573	797	1,752	1,830	1,200	630	.166
	Separator inlet.....	840	594	246	.541	1,790	1,560	230	.061
1.10 to 1.40.....	Condenser.....	1,441	612	829	1,824	1,830	1,100	730	.193
	do.....	1,317	626	691	1,520	1,660	1,200	460	.122
	Separator inlet.....	703	613	90	.198	1,810	1,680	130	.033
1.40 to 2.10.....	Condenser.....	746	632	114	.251	1,770	1,660	110	.029
	do.....	1,515	745	770	1,695	1,700	1,000	700	.185
	Separator inlet.....	802	757	45	.099	1,820	1,780	40	.010
2.10 to 2.40.....	Condenser.....	1,340	790	550	1,210	1,810	1,320	490	.130
	Separator inlet.....	674	627	47	.103	1,750	1,740	10	.003
2.40 to 3.10.....	Condenser.....	1,108	794	314	.691	1,800	1,540	260	.069
	Separator inlet.....	417	385	32	.070	930	920	10	.003
3.10 to 3.40.....	Condenser.....	562	429	133	.292	910	800	110	.029
	Separator inlet.....	453	425	28	.062	910	910	0	.000
3.40 to 4.10.....	Condenser.....	509	428	81	.178	950	860	90	.024
	Separator inlet.....	461	448	13	.029	940	920	20	.005
4.10 to 4.40.....	Condenser.....	500	455	45	.099	930	900	30	.008
	Separator inlet.....	447	425	22	.048	920	915	5	.001
4.40 to 5.10.....	Condenser.....	398	387	11	.024	920	920	0	.000
				6,430					1.485

SHEET A 8b.

Test No. 35.

Date: May 28, 1909.

Observers: W. A. Dunkley, D. F. Smith.

Time of taking sample.	Source.	Weight.				Volume.			
		Gross (gms.).	Tare (gms.).	Net (gms.).	Net (lbs.).	Jar.		Tar.	
						Total (c. c.).	Excess (c. c.).	c. c.	Gals.
<i>p. m.</i>									
12.40 to 1.10.....	Separator outlet.....	2,259	595	1,664	3,661	1,840	340	1,500	0.397
1.10 to 1.40.....	do.....	2,262	751	1,511	3,324	1,850	500	1,350	.356
1.40 to 2.10.....	do.....	1,940	608	1,332	2,930	1,800	610	1,190	.314
2.10 to 2.40.....	do.....	1,950	792	1,158	1,448	1,840	840	1,000	.265
2.40 to 3.10.....	do.....	1,822	617	1,205	2,651	1,800	800	1,000	.265
3.10 to 3.40.....	do.....	1,575	583	992	2,180	1,810	1,000	810	.214
3.40 to 4.10.....	do.....	939	435	504	1,110	930	500	430	.114
4.10 to 4.40.....	do.....	765	458	307	.675	940	700	240	.063
				8,673					1.988
Carried from sheet No. A 8a.....				6,430					1.455
				15,103	33,267				3.443
									5

Gallons per ton..... 17.215

$$\frac{3.443 \times 2,000}{400} = 17.2 \text{ gallons per ton of coal as charged.}$$

$$\frac{3.443 \times 2,000}{381} = 18.1 \text{ gallons per ton of dry coal.}$$

$$\frac{3.443 \times 2,000}{353} = 19.5 \text{ gallons per ton of coal ash and moisture free.}$$

Sheets for recording tests—Continued.

SHEET A 9a.
Test No. 35.

Date: May 28, 1909.
Observers: D. F. Smith, W. A. Dunkley.

AMMONIA.

[illegible]

Sheet A 9b.
Test No. 35.

Date: May 28, 1909.
Observer: Morgan.

[illegible]

Sheets for recording tests—Continued.

Sheet A 10.
Test No. 35.Date: May 28, 1909.
Observer: W. A. Dunkley.

TAR TUBES.

Time of taking sample.	Source.	Tank No.	Capacity of tank (cubic yards).	Gas made in period (cubic feet).	Weight of tar tube.		Weight of suspended tar and water.		
					Gross (grams).	Tare (grams).	Tank (grams).	Uncorrected (cubic feet).	Period.
<i>p. m.</i>									
12.40 to 1.05	P. and A. outlet.	8	1.026	157.1	30.098	28.569	1.523	1.485	233.5
1.08 to 1.32	do.	7	1.042	189.5	27.024	25.638	1.386	1.330	252.0
1.40 to 2.04	do.	8	1.026	207.6	27.927	26.887	1.040	1.014	210.5
2.08 to 2.29	do.	7	1.042	187.4	25.435	24.812	.623	.598	112.0
2.33 to 2.58	do.	8	1.026	197.3	21.826	21.242	.584	.570	112.7
3.03 to 3.24	do.	7	1.042	204.1	26.901	26.285	.616	.590	120.3
3.27 to 3.52	do.	8	1.026	235.5	30.926	30.363	.563	.549	129.2
3.57 to 4.19	do.	7	1.042	184.4	26.634	26.148	.486	.466	89.7
4.22 to 4.47	do.	8	1.026	205.9	25.869	25.456	.413	.403	83.0

Sheet A 10a.
Test No. 35.Date: May 24, 1909.
Observer: W. A. Dunkley.

NAPHTHALENE IN TARS.

Time of taking sample.	Tank No.	Capacity of tank (cubic feet).	Gas made in period (cubic feet).	Weight of U tube (grams).		Number of hours run.	C ₁₀ H ₈ naphthalene (milligrams).			
				Initial.	Final.		Corrected.	Tank.	Per cubic foot.	Period.
<i>p. m.</i>										
12.40 to 1.05	8	1.026	157.1	7.1087	7.1205	12	5.8	.....	5.6	880
1.08 to 1.32	7	1.042	189.5	10.0009	10.0063	15	10.4	.....	9.9	1,875
1.40 to 2.04	8	1.026	207.6	.7447	.7506	10	9.2	.....	8.9	1,848
2.08 to 2.29	7	1.042	187.4	2.2067	2.2115	10	8.1	.....	7.7	1,430
2.33 to 2.58	8	1.026	197.3	1.3814	1.3866	10	8.5	.....	8.3	1,637
3.02 to 3.23	7	1.042	204.1	7.1657	7.1696	10	7.2	.....	6.9	1,407
3.27 to 3.52	8	1.026	235.5	8.6033	8.6099	7	8.9	.....	8.7	2,050
3.57 to 4.19	7	1.042	184.4	6.5011	6.5069	10	9.1	.....	8.6	1,587
4.22 to 4.47	8	1.026	205.9	7.1667	7.1688	7	4.4	.....	4.3	887

Sheet A 10b.
Test No. 35.Date: May 24, 1909.
Observer: W. A. Dunkley.

NAPHTHALENE IN GAS.

Time of taking sample.	Tank No.	Capacity of tank (cubic feet).	Gas made in period (cubic feet).	Weight of U tube (grams).		Number of hours run.	Naphthalene (milligrams).			
				Initial.	Final.		Corrected.	Tank.	Cubic feet.	Period.
<i>p. m.</i>										
12.40 to 1.05	8	1.026	157.1	7.1655	7.1677	19	8.9	.....	8.3	1,303
1.08 to 1.32	7	1.042	189.5	2.2068	2.2170	7	12.5	.....	11.3	2,150
1.40 to 2.04	8	1.026	207.6	6.5011	6.5087	7	9.1	.....	8.4	1,745
2.08 to 2.29	7	1.042	187.4	10.8796	10.8817	13	6.4	.....	5.8	1,088
2.33 to 2.58	8	1.026	197.3	10.0013	10.0087	7	9.7	.....	8.9	1,772
3.02 to 3.23	7	1.042	204.1	.....	.....	.....	.....	.....	10.0	2,041
3.27 to 3.52	8	1.026	235.5	1.3824	1.3882	13	10.1	.....	9.4	2,200
3.57 to 4.19	7	1.042	184.4	9.0715	9.0753	13	8.1	.....	7.4	1,364
4.22 to 4.47	8	1.026	205.9	8.8950	8.9044	7	10.7	.....	9.9	2,080

COMPUTATIONS FOR ILLUMINATING-GAS TESTS.**FORM B 1.****COAL AND COKE.****I. Coal:**

A. A. No. _____ } to be taken from data cards according to sample numbers on sacks.
 Locality _____ }

Screen test: Per cent screened out by $\frac{3}{8}$ -inch bar screen = $\frac{\text{weight of screenings}}{\text{weight of total coal put over screen}}$

Analyses of coal and coke to be copied from analyses of samples taken on date of test.

Weight of coal charged to be taken from data sheet.

Weight of dry coal = weight of coal $\times$ (100 - per cent of moisture in coal).

Weight of coal, ash and moisture free = weight of coal $\times$ (100 - per cent of moisture and ash in coal).

Length of gasifying period = time of drawing less time of charging. Express in hours and minutes and also in decimals of hours.

Example: 5:11-12:38 = 4 hrs. 33 min.

= 4.55 hrs.

Place results on Sheet C 1.

II. Coke:

Weight of dry, unquenched coke from data sheet.

Per cent of dry coke from coal as charged = $\frac{\text{weight of dry coke}}{\text{weight of coal}}$

Per cent of dry coke from dry coal = $\frac{\text{weight of dry coke}}{\text{weight of dry coal}}$

Weight of coke, ash and moisture free, to be obtained from analysis of coke by multiplying weight of dry coke by (100 - per cent ash in coke).

Per cent of coke ash and moisture free on coal ash and moisture free =

$\frac{\text{weight of coke ash and moisture free}}{\text{weight of coal ash and moisture free}}$

Weight quenched coke after draining _____ hrs. From data sheet.

Per cent moisture in quenched coke.

Screen test: Weight quenched coke screened _____ pounds.

Weight coke through screen _____ pounds.

Per cent of coke falling through $\frac{3}{8}$ -inch bar screen = coke breeze = $\frac{\text{weight of screenings}}{\text{weight of coke screened}}$

Weight of lump coke = weight of coke screened - breeze.

Place results on Sheet C 1.

FORM B 2.**RETORT TEMPERATURE.**

Retort temperature, both inside and outside. Correct according to calibration curve of pyrometer, making allowance for temperature of cold junction. If readings are in centigrade scale, convert to Fahrenheit.

Plat interior and exterior curves in degrees Fahrenheit. See Sheet C 2.

Find average exterior temperature.

Place result on Sheet C 1.

FORM B 3.**PRESSURES—GAS-MADE.**

Plat volume of gas made, cubic feet, uncorrected, by five-minute intervals. Sheet C 2.

Tabulate yield of gas, uncorrected, by half-hour intervals, expressing last half hour, if incomplete, fractionally.

Example: 9 ($\frac{3}{4}$) = 20. Sheet C 3.

Total gas made, uncorrected = final meter reading - initial meter reading + the volume of gas used in ammonia and naphthalene sampling.

Example: 2357-280+9=2086. Correct for error in station meter, if any, and for temperature and pressure according to standard tables, gas saturated with moisture at a temperature of 60° F. and a barometric pressure of 30 inches. Place on sheet C 3.

Example: Temperature of gas at outlet of meter = 54° F.

Barometer = 29.6 inches; correction factor = 1.001.

Factor on station meter = 1.00.

$2077 \times 1.00 \times 1.001 = 2079$.

Find correct yield of gas by half-hour intervals in same manner as total gas. Place on sheet C 3 and plat on Sheet C 4.

Yield of gas corrected per pound of coal as charged = $\frac{\text{corrected yield}}{\text{weight of coal charged}}$

Yield of gas corrected per pound of dry coal = $\frac{\text{corrected yield}}{\text{weight of dry coal}}$

Yield of gas corrected per pound of dry coal ash and moisture free = $\frac{\text{corrected yield}}{\text{weight of coal ash and moisture free}}$

FORM B 4.

GENERAL TEMPERATURES.

Average condenser temperatures; separator inlet and outlet temperatures.

Find average temperature of water in meter.

Find average temperature of gas at outlet to meter.

Apply calibration correction to averaged temperatures from thermometer calibration sheet.

In case any readings are in the centigrade scale, convert to Fahrenheit.

FORM B 5.

CALORIMETER.

Check calculations on data sheet.

Correct gas volume to 60° F. and 30 inches barometer, according to tables.

B. t. u. gross = $\frac{\text{kilograms of water (av. outlet temperature - av. inlet temperature)} \times 3.968}{\text{corrected gas used}}$

B. t. u. net = B. t. u. - (.6 × c. c. condensed water × 3.968). Obtain the average B. t. u. by multiplying the cubic feet of gas made each half hour by the heating value of the respective samples, adding together the B. t. u.-feet thus found and dividing by the total number of feet of gas made. Place on Sheet C 3.

Plat gross and net B. t. u. according to Sheet C 4.

FORM B 6.

PHOTOMETER.

Check calculations on data sheet.

To obtain gas burned per hour proceed as follows:

Each revolution of the large hand is one-twelfth cubic foot, which, by observations of one minute, gives the rate in cubic feet per hour. The small hand passes over a dial graduated from 0 to 50. If the small hand does not pass over the zero during a test, the gas burned per hour (uncorrected) is obtained by subtracting the initial reading from the final and dividing by the time in minutes.

Example: 45-15=30.

Time, 6' 10''=6.16 min.

Consumption uncorrected = $\frac{30}{6.16}=4.87$.

If the small hand passes the zero during a test, subtract the initial reading from 50 and add it to the final.

Example: Initial 40, final 20. 50-40+20=30.

Correct consumption to 60° F. and 30 inches barometer, from temperature taken at photometer meter. Place on Sheet A 6a.

Obtain tabular number from table corresponding to average photometric reading. (This for Hefner lamp and 2,500-mm. bar.) Place on Sheet A 6a.

Candlepower = $\frac{\text{tabular number}}{\text{corrected consumption}}$

Place candlepower on Sheet C 3 and plat according to Sheet C 4.

Obtain the calculated average candlepower by multiplying the candlepower for each half hour by the cubic feet of gas made in the half hour, adding together these figures for candle-feet for all the half hours and dividing by the total make of gas. Place on Sheet C 3.

FORM B 7.

GAS ANALYSIS.

Check calculations.

CO₂, C₂H_x, O, and CO= percentages read directly when 100 c. c. sample is taken.

CH₄= $\frac{\text{vol. after CO absorption} \times (\text{vol. after explosion} - \text{vol. after absorption of CO}_2)}{\text{vol. taken for explosion}}$

This volume CH₄ indicates percentage if 100 c. c. sample is taken.

H₂= $\frac{\text{vol. after CO absorption} \left[\frac{2}{3} \{ \text{vol. after explosion} - 2 (\text{vol. after explosion} - \text{vol. after absorption}) \} \right]}{\text{vol. taken for explosion}}$

This gives percentage if 100 c. c. sample is taken.

Nitrogen is taken by difference between the sum of the O₂, CO₂, CO, C₂H, CH₄, and H₂ and 100. It should always be at least four times the oxygen, but should not be much more than 3 per cent above this figure. In case the nitrogen is excessively high or low scrutinize all the figures very carefully. Place results on Sheet C 5. Plat according to Sheet C 6.

Obtain the calculated average gas analysis by multiplying the percentage of each constituent in a half-hour sample by the cubic feet of gas made in the half hour, adding together these figures for each constituent for all half hours and dividing by the total cubic feet of gas made. Place on Sheet C 5.

FORM B 8.

TAR AND LIQUOR.

Tar from condensers. Take weight directly from Sheet A 8a for half-hour periods. The tar marked "Separator inlet" is to be counted as from condensers. Place on Sheet C 7a.

Liquor from condensers. Take weight directly from Sheet A 9a for half-hour periods. Place on Sheet C 7a.

Tar from separator outlet. Take weight directly from Sheet A 8b for half-hour intervals. Place on Sheet C 7a.

Tar in gas at outlet of separator.

The weights of suspended tar and water per cubic foot of gas, uncorrected, are obtained from Sheet A 10 and placed on Sheet C 7b, column 2. Column 1 of Sheet C 7a is obtained from column 1 of Sheet A 10; the time of emptying each aspirator tank is taken and to this time is added half of the few minutes' interval required to change tanks, it being assumed that in this interval the yield of tar does not vary materially. The weight of nonvolatile tar is the difference between the weight of the tar tube after the volatile constituents of the tar have been removed and its initial weight. Place in column 3 of Sheet C 7b. The weight of tar as sampled is calculated from this figure by multiplying by a factor to be determined experimentally for each test. The gas made in the period is not to be corrected to standard conditions, since the gas in the aspirator tank was not thus corrected. The weight of tar per period is obtained by multiplying the tar as sampled by the gas made in the period. These figures are then, for ease of comparison with other tests, calculated to even half-hour periods, a sufficient part of the second sample being added to the first to make the total equivalent to an exact half-hour run.

Example.	Period.	Weight of tar.
	28 min.	50 grams.
	31 min.	60 grams.

$$\text{Weight of tar in first half hour} = 50 + \frac{2}{31} \times 60.$$

Place in last column of sheet C 7b and also in third column of Sheet C 7c.

Total weight of tar in grams = sum of tar from condenser, tar from separator, and tar in gas passing separator.

$$\text{Total tar in cubic centimeters} = \frac{\text{weight in grams}}{\text{specific gravity of average samples}}$$

The specific gravity of average sample will be found on data sheet.

$$\text{Gallons of tar per charge} = \frac{\text{c. c. tar}}{3,785}$$

$$\text{Total gallons of tar per ton of coal as charged} = \frac{\text{gallons per charge} \times 2,000}{\text{weight of charge}}$$

$$\text{Total gallons of tar per ton of dry coal} = \frac{\text{gallons per charge} \times 2,000}{\text{weight of dry coal charged}}$$

$$\text{Total gallons of tar per ton of coal ash and moisture free} = \frac{\text{gallons per charge} \times 2,000}{\text{weight of coal ash and moisture free charged}}$$

$$\text{Percentage of tar removed by separator by half-hour intervals} = \frac{\text{weight of tar from separator}}{\text{total tar for interval}}$$

Plot total tar and liquor by half-hour intervals according to Sheet C 8.

FORM B 9.

AMMONIA.

NH₃ in liquor:

Weight of liquor for each period from data sheet.

Weight of sample = gross weight—tare weight.

Calculation: c. c. H₂SO₄ used $\times$ factor = ——— normal.

c. c. NaOH used $\times$ factor = ——— normal.

Subtract and difference = c. c. normal NH₃.

c. c. normal NH₃ $\times$.0170 = weight of NH₃ in grams.

$$\text{Percentage of NH}_3 \text{ in sample} = \frac{\text{weight of NH}_3}{\text{weight of sample for analysis}}$$

Weight of NH₃ in liquor for period = weight of liquor $\times$ percentage of NH₃.

Calculate percentage of NH₃ from condenser = sum of half-hour periods in grams.

NH₃ in gas at inlet of separator.

Calculation of analysis, as above, gives weight of NH₃ per tank.

$$\text{NH}_3 \text{ per cubic foot uncorrected} = \frac{\text{weight of NH}_3}{\text{capacity of tank}}$$

It is assumed that the temperature and pressure of gas in tank are the same as in the station meter. NH₃ for intervals of emptying tank = NH₃ per cubic foot uncorrected $\times$ uncorrected make of gas for same interval.

NH₃ for even half-hour intervals to be calculated in same manner as tar at outlet of separator. See Sheet B 8a.

Total NH₃ at inlet to separator = sum of intervals in grams.

Total NH_3 by half-hour intervals = sum of corresponding NH_3 in liquor and in gas from charge.

Total NH_3 = sum of NH_3 in liquor + NH_3 in gas.

Pounds of NH_3 per charge = $\frac{\text{weight in grams}}{453.6}$

Pounds of NH_3 per 2,000 pounds of coal as charged = $\frac{\text{pounds per charge} \times 2,000}{\text{weight of charge}}$

Pounds of NH_3 per 2,000 pounds of dry coal = $\frac{\text{pounds per charge} \times 2,000}{\text{weight of dry coal charged}}$

Pounds of NH_3 per 2,000 pounds of coal, ash and moisture free = $\frac{\text{pounds per charge} \times 2,000}{\text{weight of coal substance charged}}$

Plat total NH_3 by half-hour intervals according to Sheet C 10.

FORM B 10.

NAPHTHALENE.

Naphthalene:

Weight of naphthalene in U tubes = final weight - initial weight + correction of milligrams for each hour's run.

Naphthalene in gas (Sheet C 11a):

Weights in column 8 of Sheet A 10a indicate results per tank.

Weight of C_{10}H_8 per interval = weight per cubic foot $\times$ gas made in interval (uncorrected).

Calculate results to even half-hour periods as in Sheet B 8. Place on Sheet C 11a.

Calculate naphthalene per cubic foot of gas corrected by dividing the naphthalene per half hour (column 6 of Sheet C 11a) by the corrected gas made per half hour (column 2 of Sheet C 3). Place on Sheet C 4d.

Tabulate saturating temperature for C_{10}H_8 in gas at outlet of separator noting whether description of corresponding tar tubes shows crystalline naphthalene. Place on Sheet C 11a.

Naphthalene in tar collected by tar tubes:

Correct the milligrams of C_{10}H_8 per period as given in last column of Sheet A 10a to even half hours.

Put on Sheet C 11a, column 3.

Copy weight of tar from column 3 of Sheet C 7c to column 2 of Sheet C 11a.

Obtain percentage of naphthalene in tar by dividing column 3 by column 1.

FORM B 11.

SULPHUR.

H_2S at outlet of scrubber:

Correct meter reading to 60°F . and 30 inches barometer according to U. G. I. tables.

Weight of cadmium sulphide $\times .235$ = weight of H_2S in grams per volume of gas shown by meter.

Weight of H_2S in grams per cubic feet of gas = $\frac{\text{weight of } \text{H}_2\text{S}}{\text{volume of gas}}$

Grains of H_2S per 100 cubic feet of gas = weight of H_2S $\times 100 \times 15.432$.

Grains H_2S
1.576 = volume of H_2S in c. c.

Volume of H_2S in c. c.
28.322 = cubic feet of H_2S .

cubic feet of H_2S

Cubic feet of gas corrected to 29.92 inches and 32°F . = percentage of H_2S by volume.

SPECIMEN COMPUTATION SHEETS.

SHEET B 1.

COAL.

Test No. 35.

Coal A. A. No. 12; Harrisburg, Saline County, Ill.

Screenings.....27.9 per cent.

ANALYSIS OF COAL.

(See Sheet C 1.)

Weight charged.....	pounds..	400
Weight dry coal.....	do....	381
Weight ash and moisture free.....	do....	353
Length of gasifying period.....	4 hrs. 40 min.	4.67 hrs.

SHEET B 1a.

COKE.

Test No. 35.

Weight dry, unquenched.....	pounds..	249
Per cent dry, unquenched from coal as charged.....		62.3
Per cent dry coke from dry coal.....		65.4
Weight, coke, ash and moisture free.....	pounds.....	
Per cent coke substance on coal substance.....		61.8
Weight quenched coke after draining 63 hours.....	pounds..	343
Per cent moisture in quenched coke.....		27.4
Per cent screenings.....		6.7

Specimen computation sheets—Continued.

SHEET B 3.

Test No. 35.

GAS YIELD BY HALF-HOUR INTERVALS.

Half-hour period.	Yield, uncorrected (cubic feet).	Yield, corrected (cubic feet).	Half-hour period.	Yield, uncorrected (cubic feet).	Yield, corrected (cubic feet).
1.....	185	178	7.....	232	223
2.....	195	187	8.....	176	169
3.....	210	202	9.....	91	87
4.....	228	219	9 $\frac{1}{2}$	7	6
5.....	244	234			
6.....	246	236		1,814	1,741

Gas made, total uncorrected	cubic feet..	1,814
Samples for $C_{10}H_8$		9
Samples for NH_3		9
Samples for H_2S		1
		1,833

Average barometric pressure.....	inches..	29.3
Average temperature.....	°F..	70
Factor for conversion.....		.95
Corresponding yield = $1,833 \times .95$	cubic feet..	1,741
Corresponding yield per pound coal as charged.....	do....	4.35
Corresponding yield per pound dry coal.....	do....	4.57
Corresponding yield per pound dry coal ash and moisture free.....	do....	4.93

SHEET B 5.

Test No. 35.

AVERAGE HEAT VALUE OF GAS.

Half-hour period.	Gas made (cubic feet).	Gross heat value (B. t. u.).	Gross weight (grams).	Net heat value (B. t. u.).	Net weight (grams).
1.....	178	<i>a</i> 850	151,200	<i>a</i> 780	138,800
2.....	187	775	144,900	706	132,000
3.....	202	695	140,400	624	126,100
4.....	219	676	148,000	610	133,500
5.....	234	626	146,500	555	129,800
6.....	236	582	137,300	524	123,600
7.....	223	513	114,400	452	100,700
8.....	169	455	77,000	404	68,300
9.....	87	402	35,000	351	30,500
Average heat value.....	1,735		1,094,700 632		983,300 568

a Interpolating value for lost sample.

SHEET B 6.

Test No. 35.

CANDLEPOWER OF GAS.

Half-hour period.	Gas made (cubic feet).	Results averaged.		Half-hour period.	Gas made (cubic feet).	Results averaged.	
		Candle-power.	Candle feet.			Candle-power.	Candle feet.
1.....	178	22.7	4,040	7.....	223	11.1	2,470
2.....	187	21.1	3,950	8.....	169	6.2	1,050
3.....	202	18.5	3,740	9.....	87	1.2	104
4.....	219	17.8	3,900				
5.....	234	15.7	3,680		1,735	15.2	26,454
6.....	236	14.9	3,520				

Specimen computation sheets—Continued.

SHEET B 7.

Test No. 35.

GAS ANALYSES.

Half-hour period.	Gas made, cor- rected (cubic feet).	CO ₂ .		CnH _{2n} .		O ₂ .		CO.		CH ₄ .		H ₂ .		N ₂ .	
		Per cent.	Weight (grams).	Per cent.	Weight (grams).	Per cent.	Weight (grams).	Per cent.	Weight (grams).	Per cent.	Weight (grams).	Per cent.	Weight (grams).	Per cent.	Weight (grams).
1....	178	3.2	570	8.4	1,490	0.6	107	8.7	1,550	53.9	9,600	20.1	3,580	5.1	907
2....	187	3.7	691	7.6	1,420	.7	131	7.9	1,470	46.1	8,610	27.0	5,050	7.0	1,310
3....	202	3.1	625	5.8	1,170	.6	121	9.0	1,820	40.5	8,180	37.1	7,500	3.9	787
4....	219	3.2	700	4.8	1,050	.8	175	8.4	1,840	37.3	8,170	39.3	8,600	6.3	1,380
5....	234	2.6	608	2.8	655	.8	187	8.4	1,960	34.7	8,110	48.1	11,300	2.7	632
6....	236	2.1	495	1.9	449	1.1	260	7.6	1,790	30.5	7,200	49.3	11,600	7.5	1,770
7....	223	1.6	357	.9	206	.8	178	7.5	1,670	23.3	5,200	59.8	13,300	6.1	1,360
8....	169	1.2	203	.0	0	.4	68	6.5	1,100	15.1	2,550	72.7	12,300	4.1	693
9....	87	1.0	87	.2	17	2.3	200	4.9	426	6.4	556	68.7	5,970	16.5	1,440
1,735		2.5	4,336	3.7	6,457	.8	1,427	7.9	13,626	33.5	58,176	45.6	19,200	6.0	10,299

SHEET B 8.

Test No. 35.

CALCULATION OF CUBIC FEET OF GAS FOR PERIODS SHOWN ON SHEET A 10, TAKEN FROM METER READINGS OF 5-MINUTE INTERVALS.

(See Sheet A 4.)

The first period is taken from 12.40 to 1.05 p. m. To this is added $1\frac{1}{2}$ minutes of the next period, or three-tenths of the quantity of gas flowing in the 5-minute interval between 1.05 and 1.10 p. m. In the period from 1.06 $\frac{1}{2}$ to 1.36, to the readings from 1.10 to 1.35 are added 3.5 of the former period and one-fifth of the period following.

$$12.40 \text{ to } 1.06\frac{1}{2} \text{ p. m.:}$$

$$154 + \frac{1\frac{1}{2} \times 3.1}{5} = 157.1.$$

$$1.06\frac{1}{2} \text{ to } 1.36:$$

$$\frac{3.5 \times 31}{5} + (346 - 185) + \frac{1}{5} \times 34 = 189.5.$$

$$1.36 \text{ to } 2.06:$$

$$\frac{4}{5} \times 34 + (553 - 380) + \frac{37}{5} = 207.6.$$

$$2.06 \text{ to } 2.31:$$

$$\frac{4 \times 37}{5} + (740 - 590) + \frac{1 \times 39}{5} = 187.4.$$

$$2.31 \text{ to } 3.00\frac{1}{2}:$$

$$\frac{4 \times 39}{5} + (980 - 818) + \frac{.5 \times 41}{5} = 197.3.$$

$$3.00\frac{1}{2} \text{ to } 3.25\frac{1}{2}:$$

$$\frac{4.5 \times 41}{5} + (1184 - 1021) + \frac{.5 \times 42}{5} = 204.1.$$

$$3.25\frac{1}{2} \text{ to } 3.54\frac{1}{2}:$$

$$\frac{4.5 \times 42}{5} + (1385 - 1226) + \frac{4.5 \times 43}{5} = 235.5.$$

$$3.54\frac{1}{2} \text{ to } 4.20:$$

$$\frac{.5 \times 43}{5} + (1605 - 1428) + \frac{.5 \times 31}{5} = 184.4.$$

$$4.20\frac{1}{2} \text{ to } 5.20:$$

$$\frac{4.5 \times 31}{5} + (1814 - 1636) = 205.9.$$

Specimen computation sheets—Continued.

SHEET B 8a

Test No. 35.

CALCULATION OF TAR SUSPENDED IN GAS AT OUTLET OF SEPARATOR FOR HALF-HOUR PERIODS, FROM WEIGHTS OF TAR PER PERIOD AS SAMPLED.

(See Sheet C 7c.)

The duration of the first period was 26.5 minutes. To calculate for 30-minute period, 3.5 minutes of the next period are added to this, i. e., in the next period 48 grams of tar were delivered, and the rate per minute for this period is $\frac{48}{29.5}$. For 3 minutes it will be $3.5 \times \frac{48}{29.5}$.

For the half-hour period No. 2, $29 - 3.5 = 26.0$ minutes are taken plus 4 minutes of the period following.

$$(1) \quad 44.7 + \frac{3.5 \times 48}{29.5} = 50.4.$$

$$(2) \quad \frac{26.0 \times 48}{29.5} + \frac{4 \times 65.4}{30} = 51.0.$$

$$(3) \quad \frac{26 \times 65.4}{30} + \frac{4 \times 46.7}{27} = 63.5.$$

$$(4) \quad \frac{23 \times 46.7}{27} + \frac{7 \times 47.3}{29.5} = 51.0.$$

$$(5) \quad \frac{22.5 \times 47.3}{29.5} + \frac{7.5 \times 46.5}{25} = 50.0.$$

$$(6) \quad \frac{17.5 \times 46.5}{25} + \frac{12.5 \times 45}{29} = 52.0.$$

$$(7) \quad \frac{16.5 \times 45}{29} + \frac{13.5 \times 49.9}{26} = 52.5.$$

$$(8) \quad \frac{12.5 \times 49.9}{26} + \frac{17.5 \times 26.5}{59.5} = 15.6.$$

$$(9) \quad \frac{30 \times 20.5}{59.5} = 10.3 = 14.4$$

$$\frac{12 \times 20.5}{59.5} = 4.1.$$

SHEET B 9.

AMMONIA.

Test No. 35.

Quantity of gas taken for determining ammonia.

Time of sampling.	Meter readings (cubic feet).		Time of sampling.	Meter readings (cubic feet).	
	Corrected.	Uncorrected.		Corrected.	Uncorrected.
12.40 to 1.04 p. m.	148	149	3.35 to 4.03 p. m.	1,488	222
1.04 to 1.36 p. m.	353	206	4.03 to 4.42 p. m.	1,726	239
1.36 to 2.07 p. m.	568	216	4.42 to 5.12 p. m.	1,809	84
2.07 to 2.33 p. m.	764	197			
2.33 to 3.04 p. m.	1,013	250		1,818	1,818
3.04 to 3.35 p. m.	1,267	255			

Aspirator tanks, 9.

Calculation of ammonia in gas for half-hour intervals.

(See Sheet C 9a.)

Time of sampling.	Weight of NH ₃ .	
	Weight for period (grams).	Corrected weight (grams).
12.40 to 1.04 p. m.	32.6	24 - 24 = 32.6
1.04 to 1.36 p. m.	40.8	32 $\left\{ \begin{array}{l} 6 = 7.6 \\ 26 = 32.2 \end{array} \right.$ 40.2
1.36 to 2.07 p. m.	53.0	31 $\left\{ \begin{array}{l} 4 = 6.8 \\ 27 = 46.2 \end{array} \right.$ 40.0
2.07 to 2.33 p. m.	56.5	26 $\left\{ \begin{array}{l} 3 = 6.5 \\ 23 = 50.0 \end{array} \right.$ 52.7
2.33 to 3.05 p. m.	19.1	32 $\left\{ \begin{array}{l} 7 = 4.2 \\ 25 = 14.9 \end{array} \right.$ 54.2
3.05 to 3.35 p. m.	94.5	30 $\left\{ \begin{array}{l} 5 = 15.7 \\ 25 = 78.8 \end{array} \right.$ 30.6
3.35 to 4.04 p. m.	52.5	29 $\left\{ \begin{array}{l} 5 = 9.1 \\ 24 = 43.4 \end{array} \right.$ 87.9
4.04 to 4.42 p. m.	73.5	38 $\left\{ \begin{array}{l} 6 = 11.6 \\ 30 = 61.9 \end{array} \right.$ 55.0
4.42 to 5.12 p. m.	21.6	35 $\left\{ \begin{array}{l} 21 = 33.8 \\ 30 = 2.6 \end{array} \right.$ 58.1

Specimen computation sheets—Continued.

SHEET B 11b.

Test No. 35.

WEIGHT OF NAPHTHALENE.*Weight of naphthalene ($C_{10}H_8$) in tar for half-hour periods.*

$$\begin{aligned} \frac{.880 - 3.5 \times 1.875}{29.5} &= 1.18. \\ \frac{26 \times 1.875}{29.5} + \frac{4 \times 1.848}{30} &= 1.896. \\ \frac{26 \times 1.848}{30} + \frac{4 \times 1.430}{27} &= 1.81. \\ \frac{23 \times 1.430}{27} + \frac{7 \times 1.637}{29.5} &= 1.606. \\ \frac{22.5 \times 1.637}{29.5} + \frac{7.5 \times 1.407}{25} &= 1.713. \end{aligned}$$

$$\begin{aligned} \frac{17.5 \times 1.407}{25} + \frac{12.5 \times 2.050}{29} &= 1.875. \\ \frac{16.5 \times 2.050}{29} + \frac{13.5 \times 1.587}{26} &= 1.992. \\ \frac{12.5 \times 1.587}{26} + \frac{17.5 \times .887}{59.5} &= .996. \\ \frac{42.0 \times .887}{59.5} &= .628. \end{aligned}$$

Weight of naphthalene in ($C_{10}H_8$) in gas for half-hour intervals.

$$\begin{aligned} 1.304 + \frac{3.5 \times 2.27}{29.5} &= 1.573. \\ \frac{26 \times 2.15}{29.5} + \frac{4 \times 1.745}{30} &= 2.13. \\ \frac{26 \times 1.745}{30} + \frac{4 \times 1.088}{27} &= 1.71. \\ \frac{23 \times 1.088}{27} + \frac{7 \times 1.772}{29.5} &= 1.35. \\ \frac{22.5 \times 1.772}{29.5} + \frac{7.5 \times 2.04}{25} &= 1.96. \end{aligned}$$

$$\begin{aligned} \frac{17.5 \times 2.04}{25} + \frac{12.5 \times 2.20}{29} &= 2.38. \\ \frac{16.5 \times 2.20}{29} + \frac{13.5 \times 1.364}{26} &= 1.96. \\ \frac{12.5 \times 1.364}{26} + \frac{17.5 \times 2.08}{59.5} &= 1.26. \\ \frac{42 \times 2.08}{59.5} &= 1.47. \end{aligned}$$

SHEET B 11d.

Test No. 35.

NAPHTHALENE DATA.

Half-hour period.	Weight of naphthalene (grams).	Yield of gas corrected (cubic feet).	Weight of naphthalene per cubic foot (grams).	Temperature of naphthalene saturated ($^{\circ}$ F.).
1.....	1.57	178	8.8	60
2.....	2.13	187	11.4	61
3.....	1.71	202	8.5	60
4.....	1.35	219	6.2	54
5.....	1.96	234	8.4	60
6.....	2.38	236	10.1	63
7.....	1.96	223	8.8	60
8.....	1.26	169	7.5	59
9.....	1.47	93	15.8	70
Total			85.5	550
Average			9.5	61

TEMPERATURE AND WEIGHT OF SATURATED NAPHTHALENE VAPOR.

Temperature ($^{\circ}$ F.).	Weight (grams).
70	15.5
60	8.4
	7.1
50	4.5
	3.9

SHEETS FOR RECORDING COMPUTED DATA.

SHEET C 1.
Test No. 35.

Date: May 23, 1909.
Coal: Harrisburg, Ill.

RETORT DATA.

Coal A. A. No. 12.

Mine location: Harrisburg, Ill.

Per cent screened out by $\frac{3}{4}$ -inch bar screen: 27.9.

Weight of coal charged.....pounds... 400

Weight of dry coal.....do... 381

Weight of coal ash and moisture free.....do... 353

Weight of dry coke.....do... 249

Weight of coke drawn, ash and moisture free.....do... 218

Per cent on coal charged.....do... 62.3

Per cent on dry coal.....do... 65.4

Per cent on coal substance.....do... 61.8

Length of gasifying period.....4 hrs. 40 min. (4.67 hrs.)

Average temperature outside retort.....° F.. 1,779

For make of gas and retort temperature, both inside and outside, see curves, Sheet C 2 (fig. 7).

Moisture in quenched coke after draining 63 hours.....per cent... 27.4

Coke breeze (through $\frac{3}{4}$ -inch bar screen).....do... 6.7

Lump coke.....do... 93.3

Remarks on appearance of coal: Over $\frac{3}{4}$ -inch screen; bright and clean; lumps up to 5 inches.

Remarks on appearance of coke: Dark color; easily broken.

Remarks on condition of retort: Badly covered on top with carbon; temperature low.

ANALYSIS OF COAL AND COKE.

	Coal as charged.	Dry coal.	Dry coke.
Moisture.....	4.66		
Ash.....	7.19	7.54	12.30
Volatile matter.....	34.44	36.13	2.22
Fixed carbon.....	53.71	56.33	85.48
Sulphur separately determined.....	100.00	100.00	100.00
B. t. u. per pound.....	12,919	13,550	12,427

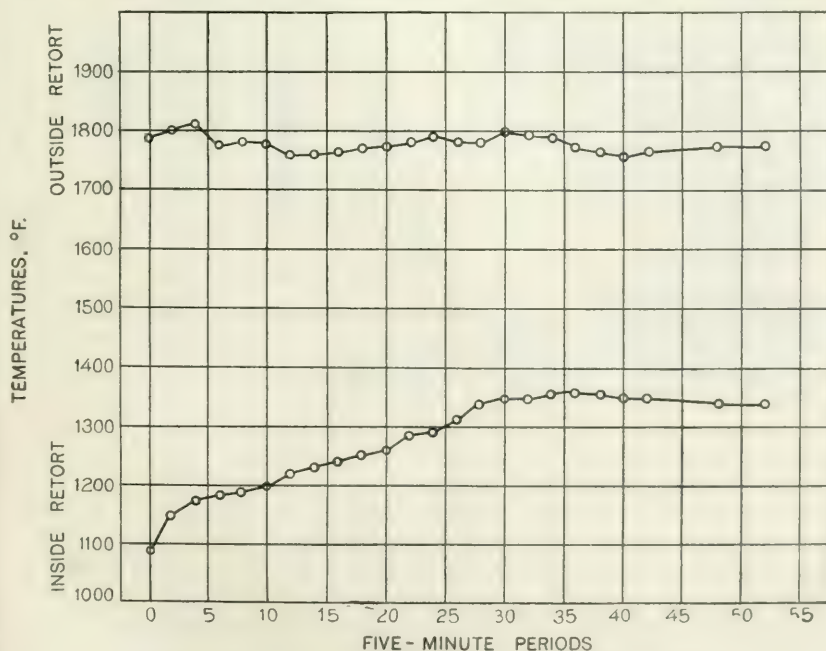


FIGURE 7.—Retort temperatures, 5-minute periods, test 35 (Sheet C 2).

Sheets for recording computed data—Continued.

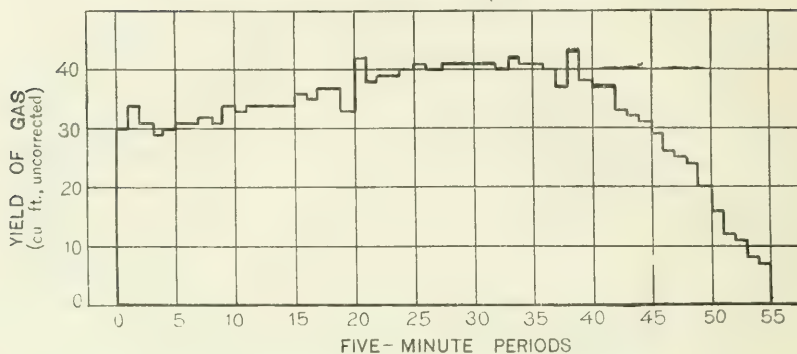


FIGURE 8. —Yield of gas, 5-minute periods, test 35 (Sheet C 2).

SHEET C 3.
Test No. 35.

Date: May 28, 1909.
Coal: Harrisburg, Ill.

GAS MADE.

Total quantity of gas made (corrected).....cubic feet.. 1,741
Gas per pound of coal as charged.....do.... 4.35
Gas per pound of dry coal.....do.... 4.57
Gas per pound of coal, ash and moisture free.....do.... 4.93

For make of gas (uncorrected) by 5-minute intervals, see curve, Sheet C 2 (fig. 8).

Half-hour period.	Gas made, corrected (cubic feet).		Candle-power.	Heating value (B. t. u.).	
	Per charge.	Per 2,000 pounds coal charged.		Gross.	Net.
1.....	178	890	22.7	<i>a</i> 670	<i>a</i> 616
2.....	187	935	21.1	775	706
3.....	202	1,010	18.5	695	624
4.....	219	1,095	17.8	676	610
5.....	234	1,170	15.7	626	555
6.....	236	1,180	14.9	582	524
7.....	223	1,115	11.1	513	452
8.....	169	845	6.2	455	404
9.....	87	435	1.2	402	351
9½.....	6	30			
Average.....			15.2	<i>b</i> 632	<i>b</i> 568
Proportional sample.....			16.9	<i>c</i> 654	<i>d</i> 582

a Leak in connections; no good.

b In calculating these averages, the value for test half hours was interpolated as 850 gross and 780 net.

c Average of two determinations, 641 and 666.

d Average of two determinations, 569 and 594.

For graphic representation of above, see curves, Sheet C 4 (fig. 9).

Remarks on any of above:

Sheets for recording computed data—Continued.

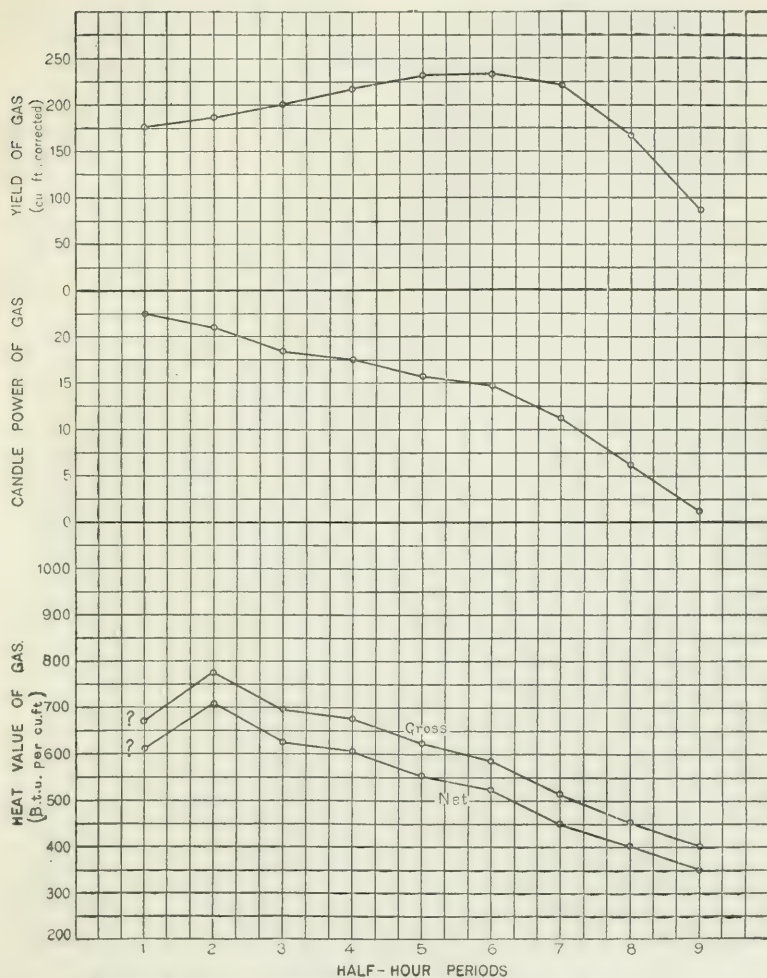


FIGURE 9.—Yield and quality of gas, half-hour periods, test 35 (Sheet C 1).

SHEET C 5.
Test No. 35.Date: May 28, 1909.
Coal: Harrisburg, Ill.

GAS ANALYSES.

Half-hour period.	CO ₂ .	C _n H _{2n} , etc.	O ₂ .	CO.	CH ₄ .	H ₂ .	N ₂ .
1.....	3.2	8.4	0.6	8.7	53.9	20.1	5.1
2.....	3.7	7.6	.7	7.9	46.1	27.0	7.0
3.....	3.1	5.8	.6	9.0	40.5	37.1	3.9
4.....	3.2	4.8	.8	8.4	37.3	39.3	6.3
5.....	2.6	2.8	.8	8.4	34.7	48.1	2.7
6.....	2.1	1.9	1.1	7.6	30.5	49.3	7.5
7.....	1.6	.9	.8	7.5	23.3	59.8	6.1
8.....	1.2	.0	.4	6.5	15.1	72.7	4.1
9.....	1.0	.2	2.3	4.9	6.4	68.7(?)	16.5(?)
Proportional tank.....	3.2	4.2	1.2	7.8	33.1	43.8	7.0
Computed average.....	2.5	3.7	.8	7.9	33.5	45.6	6.0

For graphic representation of above, see curves, Sheet C 6 (fig. 10).

Remarks on any of above:

Sheets for recording computed data—Continued.

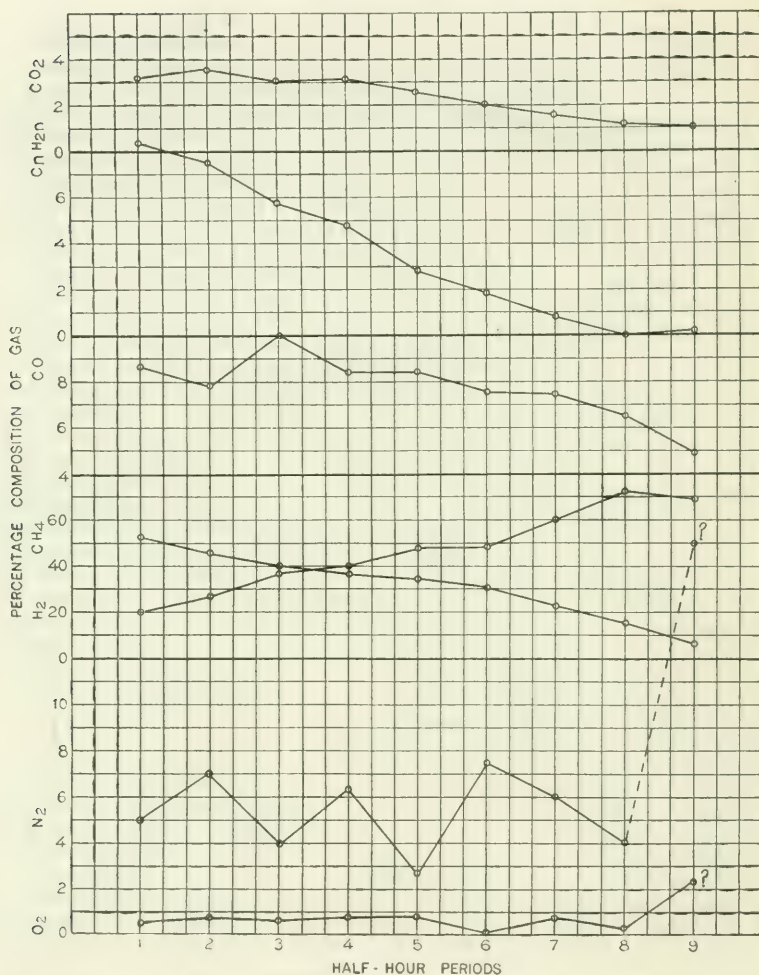


FIGURE 10.—Composition of gas, half-hour periods, test 35 (Sheet C 6).

SHEET C 7a.
Test No. 35.Date: May 28, 1909.
Coal: Harrisburg, Ill.

WEIGHT OF LIQUOR AND TAR.

WEIGHT OF AMMONIACAL LIQUOR AND TAR FROM COAL CHARGED, BY HALF-HOUR INTERVALS (GRAMS).

Half-hour period.	Weight of liquor from condenser.	Weight of tar.			Total.
		From condenser.	From separator.	Passing separator.	
1.	3,602	2,715	1,664	50.4	4,429.4
2.	2,320	1,610	1,511	51.0	3,172.0
3.	1,447	929	1,332	63.5	2,324.5
4.	887	597	1,158	51.0	1,806.0
5.	500	346	1,205	50.0	1,601.0
6.	197	161	992	52.0	1,205.0
7.	116	94	504	52.5	650.5
8.	61	67	307	15.6	389.6
9.		11		14.4	25.4
	9,130	6,530	8,673	400.4	15,603.4

*Sheets for recording computed data—Continued.***WEIGHT OF LIQUOR AND TAR—Continued.**

WEIGHT OF AMMONIACAL LIQUOR AND TAR PER TON OF COAL AS CHARGED, BY HALF-HOUR INTERVALS (POUNDS).

Half-hour period.	Weight of liquor from condenser.	Weight of tar.			Total.
		From condenser.	From separator.	Passing separator.	
1.....	39.70	29.85	18.30	0.55	48.70
2.....	25.57	17.71	16.62	.55	34.88
3.....	15.98	10.22	14.65	.69	25.56
4.....	9.77	6.56	7.24	.55	14.35
5.....	5.51	3.80	13.25	.55	17.60
6.....	2.17	1.67	10.90	.57	13.14
7.....	1.28	1.03	5.55	.57	7.15
8.....	.67	.73	3.37	.17	4.27
9.....		.12		.16	.28
	100.65	71.69	89.88	4.36	165.93

For graphic representation of above, see Sheet C 8 (fig. 11).

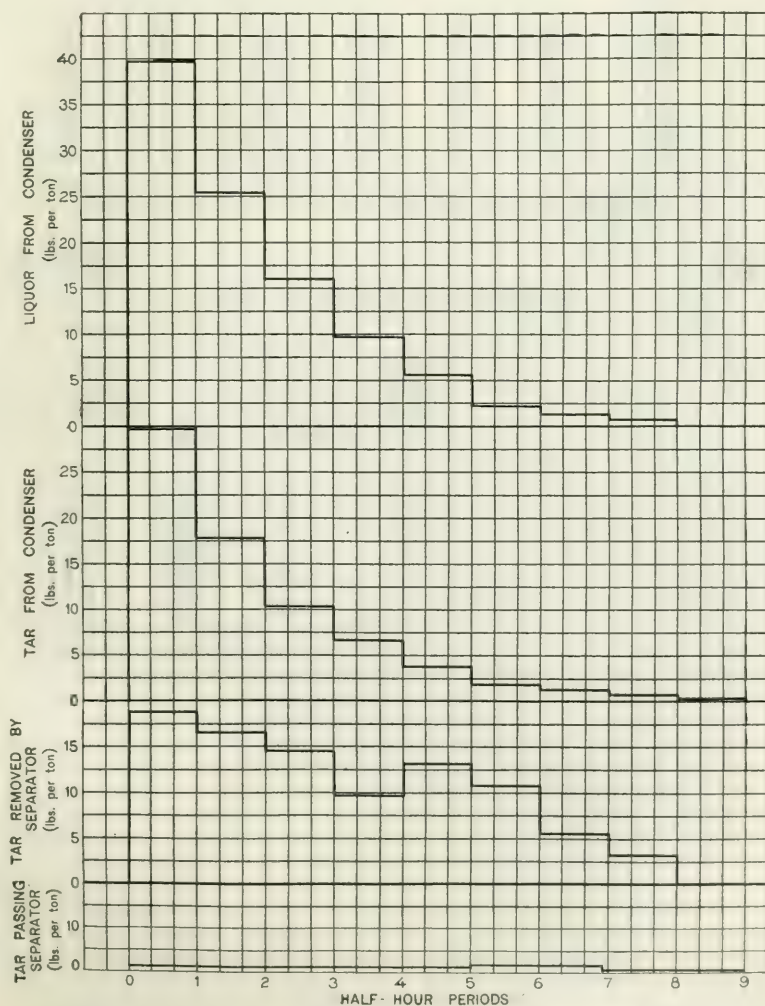


FIGURE 11.—Yield of liquor and tar, half-hour periods, test 35 (Sheet C 8).

*Sheets for recording computed data—Continued.*SHEET C 7b.
Test No. 35.Date: May 28, 1909.
Coal: Harrisburg, Ill.**TAR AT INLET AND OUTLET OF SEPARATOR.**

[All weights in grams.]

AT INLET.

[Not taken.]

AT OUTLET.

Sampling period and time out (minutes).	Weight of suspended material per cubic foot of gas, uncorrected.			Gas made in sampling period per cubic foot, uncorrected.	Weight of tar as sampled.	
	Tar and water.	Nonvolatile tar.	Tar as sampled, calculated. ^a		Per sampling period.	Per half-hour period, calculated.
26.5	1.485	0.190	0.285	157.1	44.7	50.4
29.5	1.330	.169	.253	189.5	48.0	51.0
30.0	1.014	.210	.315	207.6	65.4	63.5
27.0	.598	.166	.249	187.4	46.7	51.0
29.5	.570	.160	.240	197.3	47.3	50.0
25.0	.590	.152	.228	204.1	46.5	52.0
29.0	.549	.128	.192	235.5	45.0	52.5
26.0	.466	.072	.108	184.4	19.9	15.6
59.5	.403	.067	.100	205.9	20.5	^b 14.4

^a Tar as sampled equals nonvolatile tar multiplied by 1.5, as determined.^b 42 minutes.SHEET C 7c.
Test No. 35.Date: May 28, 1909.
Coal: Harrisburg, Ill.**ELIMINATION OF TAR BY SEPARATOR.**

Half-hour period.	Actual weight of tar removed (grams).	Calculated weight of tar—		Per cent of sum of tar removed.	Average temperature at inlet (°F.).
		At outlet (grams).	At Inlet (grams).		
1.....	1,664	50.4	1,714.4	97.0	159
2.....	1,511	51.0	1,562.0	96.7	128
3.....	1,332	63.5	1,395.5	95.5	105
4.....	1,158	51.0	1,209.0	95.8	99
5.....	1,205	50.0	1,255.0	96.0	106
6.....	992	52.0	1,044.0	95.0	106
7.....	504	52.5	556.5	90.5	101
8.....	307	15.6	322.6	95.4	93
9.....	0 (?)	14.4	14.4	.....	89
	8,673	400.4	9,073.4	95.2	110

Sheets for recording computed data—Continued.

SHEET C 9a.
Test No. 35.Date: May 28, 1909.
Coal: Harrisburg, Ill.

AMMONIA.

AMMONIA IN LIQUOR FROM CONDENSERS.

Length of sampling period (minutes).	NH ₃ in sample (per cent).	Weight of NH ₃ .			
		Total, in sample (grams).	Per minute, calculated (grams).	Per half-hour period, calculated.	
				Grams.	Pounds.
30	1.19	42.90	1.43	(1) 42.90	0.0945
30	.92	21.26	.71	(2) 21.26	.0468
30	1.96	28.40	.94	(3) 28.40	.0625
30	2.71	24.10	.80	(4) 24.10	.0530
30	2.40	12.00	.40	(5) 12.00	.0264
30	2.00	3.94	.13	(6) 3.94	.0087
30	2.06	2.39	.08	(7) 2.39	.0053
30	2.10	1.28	.04	(8) 1.28	.0028
				136.27	.2998

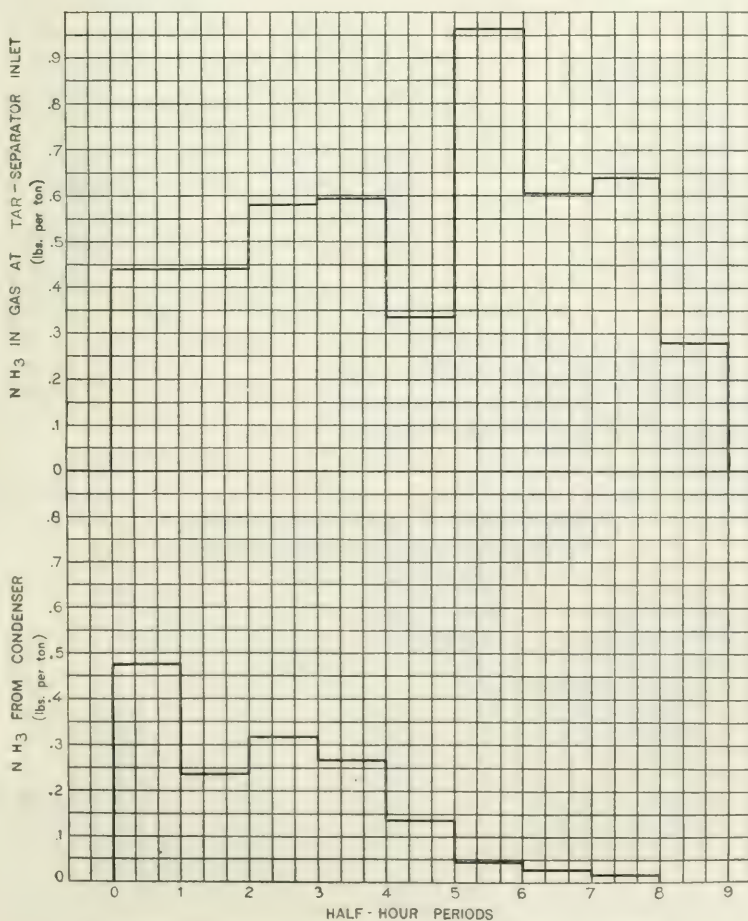


FIGURE 12.—Yield of ammonia, half-hour periods, test 35 (Sheet C 10).

*Sheets for recording computed data—Continued.***AMMONIA—Continued.****AMMONIA IN GAS AT INLET TO SEPARATOR.**

Sampling period and time out (minutes).	Weight of NH ₃ per cubic foot of gas (grams).	Gas made in period, uncorrected (cubic feet).	Weight of NH ₃ in sampling period (grams).	Weight of NH ₃ per half-hour period, calculated.	
				Grams.	Pounds.
24	0.219	149	32.6	(1) 40.2	0.0885
32	.198	206	40.8	(2) 40.0	.0880
31	.245	216	53.0	(3) 52.7	.1160
26	.287	197	56.5	(4) 54.2	.1190
32	.076	250	19.1	(5) 30.6	.0674
30	.370	255	94.5	(6) 87.9	.1930
29	.236	222	52.5	(7) 55.0	.1210
38	.307	239	73.5	(8) 58.1	.1280
30	.257	84	21.6	(9) 25.4	.0559
			444.1	444.1	.9769

AMMONIA PER CHARGE AND PER TON OF COAL, BY HALF-HOUR PERIODS.

Half-hour period.	NH ₃ per charge (pounds).		NH ₃ per ton of coal (pounds).		
	From condenser.	At separator inlet.	From condenser.	At separator inlet.	Total.
1.....	0.0945	0.0885	0.472	0.442	0.914
2.....	.0468	.0880	.234	.440	.674
3.....	.0625	.1160	.312	.580	.892
4.....	.0530	.1190	.265	.595	.860
5.....	.0264	.0674	.132	.337	.469
6.....	.0087	.1930	.043	.965	1.008
7.....	.0053	.1210	.026	.605	.631
8.....	.0028	.1280	.014	.640	.654
9.....		.0559		.280	.280
	.2998	.9769	1.500	4.88	6.38

Total NH₃ per 2,000 pounds of coal as charged.....pounds.. 6.38Total NH₃ per 2,000 pounds of dry coal.....do..... 6.70Total NH₃ per 2,000 pounds of coal, ash and mixture per.....do..... 7.2

For graphic representation of ammonia yield, see Sheet C 10 (fig. 12).

SHEET C 11a.
Test No. 35.Date: May 24, 1909.
Coal: Harrisburg, Ill.**NAPHTHALENE AT OUTLET OF SEPARATOR.****NAPHTHALENE DISSOLVED IN SUSPENDED AIR.**

[All weights in grams.]

Half-hour period.	Weight of tar from Sheet C 7c.	Per cent of naphthalene in tar.	Weight of naphthalene in tar.
1.....	50.4	2.3	1.180
2.....	51.0	3.7	1.896
3.....	63.5	2.8	1.810
4.....	51.0	3.1	1.606
5.....	50.0	3.4	1.713
6.....	52.0	3.6	1.875
7.....	52.5	3.8	1.992
8.....	15.6	6.2	.966
9 (42 minutes).....	14.4	4.4	.628
	400.4	Av. 3.7	13.666

Sheets for recording computed data—Continued.

NAPHTHALENE AT OUTLET OF SEPARATOR—Continued.

NAPHTHALENE AS VAPOR IN GAS.

Sampling period and time out (minutes).	Weight of naphthalene per cubic foot of gas, uncorrected.	Gas made in period, uncorrected (cubic feet).	Weight of naphthalene in sampling period.	Weight of naphthalene calculated to half-hour periods.
26.5	.0083	157	1.303	(1) 1.57
29.5	.0113	189	2.150	(2) 2.13
30.0	.0084	207	1.745	(3) 1.71
27.0	.0058	187	1.088	(4) 1.35
29.5	.0089	197	1.772	(5) 1.96
25.0	.0100	204	2.041	(6) 2.38
23.0	.0094	235	2.200	(7) 1.96
26.0	.0074	184	1.364	(8) 1.26
59.5	.0099	206	2.080	(9) 1.47
				15.79

SHEET C 11b.
Test No. 35.

Date: May 24, 1909.
Coal: Harrisburg, Ill.

TOTAL WEIGHT OF NAPHTHALENE.

Weight of tar from condenser.....	grams..	6,530
Weight of tar from separator.....	do.....	8,673
		15,203
Per cent of naphthalene in condenser tar.....		2.5
Per cent of naphthalene in separator tar.....		
		380.00
Weight of tar passing separator as mist.....	grams..	400
Per cent of naphthalene in tar.....		3.7
		14.80
Weight of naphthalene as vapor in gas passing separator.....	grams..	15.79
Total weight of naphthalene per charge of coal.....	do....	410.59
Total weight of naphthalene per 2,000 pounds of—		
Coal as charged.....	do....	2,042.00
Dry coal.....	do.....	
Coal substance.....	do.....	

SHEET C 11c.
Test No. 35.

Date: May 24, 1909.
Coal: Harrisburg, Ill.

NAPHTHALENE AND SULPHUR.

NAPHTHALENE PER CUBIC FOOT OF GAS AT SEPARATOR.

[All weights in milligrams.]

Half-hour period.	Naphthalene as vapor in gas per cubic foot, corrected.		Temperature of naphthalene saturated.		Average temperature of separator.	
	Inlet.	Outlet.	Inlet.	Outlet.	Inlet.	Outlet.
1.....		8.8		60	See Sheet C 7c.	130
2.....		11.4		64		116
3.....		8.5		60		103
4.....		6.2		54		100
5.....		8.4		60		101
6.....		10.1		63		99
7.....		8.8		60		96
8.....		7.5		59		93
9.....		15.8		70		92
		9.5				105

SULPHUR.

Hydrogen sulphide at outlet of fresh-water scrubber:		
Per cubic foot.....	milligrams..	900
Per 100 cubic feet.....	grains..	1,390
Hydrogen sulphide at outlet of iron-oxide purifier:		
Test with lead acetate paper.....		Negative.
Total sulphur in purified gas determined on proportional sample:		
Per cubic foot.....	milligrams..	Not taken.
Per 100 cubic feet.....	grains..	Not taken.

PUBLICATIONS ON FUEL TESTING.

The following publications, except those to which a price is affixed, can be obtained free by applying to the Director of the Bureau of Mines, Washington, D. C. The priced publications can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

PUBLICATIONS OF THE BUREAU OF MINES.

BULLETIN 1. The volatile matter of coal, by H. C. Porter and F. K. Ovitz. 1910. 56 pp., 1 pl.

BULLETIN 2. North Dakota lignite as a fuel for power-plant boilers, by D. T. Randall and Henry Kreisinger. 1910. 42 pp., 1 pl.

BULLETIN 3. The coke industry of the United States as related to the foundry, by Richard Moldenke. 1910. 32 pp.

BULLETIN 4. Features of producer-gas power-plant development in Europe, by R. H. Fernald. 1910. 27 pp., 4 pls.

BULLETIN 5. Washing and coking tests of coal at Denver, Colo., by A. W. Belden, G. R. Delamater, J. W. Groves, and K. M. Way. 1910. 62 pp.

TECHNICAL PAPER 1. The sampling of coal in the mine, by J. A. Holmes. 1911. 16 pp.

TECHNICAL PAPER 2. The escape of gas from coal, by H. C. Porter and F. K. Ovitz. 14 pp.

TECHNICAL PAPER 3. Specifications for the purchase of fuel oil for the Government, with directions for sampling oil and natural gas, by I. C. Allen. 1911. 13 pp.

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

PROFESSIONAL PAPER 48. Report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. 1906. In three parts. 1492 pp., 13 pls. \$1.50.

BULLETIN 261. Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. 1905. 172 pp. 10 cents.

BULLETIN 290. Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905, by J. A. Holmes. 1906. 240 pp. 20 cents.

BULLETIN 325. A study of four hundred steaming tests made at the fuel-testing plant, St. Louis, Mo., 1904, 1905, and 1906, by L. P. Breckenridge. 1907. 196 pp. 20 cents.

BULLETIN 332. Report of the United States fuel-testing plant at St. Louis, Mo., January 1, 1906, to June 30, 1907; J. A. Holmes, in charge. 1908. 299 pp. 25 cents.

BULLETIN 334. The burning of coal without smoke in boiler plants; a preliminary report, by D. T. Randall. 1908. 26 pp. 5 cents.

BULLETIN 336. Washing and coking tests of coal and cupola tests of coke, by Richard Moldenke, A. W. Belden, and G. R. Delamater. 1908. 76 pp. 10 cents.

BULLETIN 343. Binders for coal briquets, by J. E. Mills. 1908. 56 pp.

BULLETIN 362. Mine sampling and chemical analyses of coals tested at the United States fuel-testing plant, Norfolk, Va., in 1907, by J. S. Burrows. 1908. 23 pp. 5 cents.

BULLETIN 363. Comparative tests of run-of-mine and briquetted coal on locomotives, including torpedo-boat tests and some foreign specifications for briquetted fuel, by W. F. M. Goss. 1908. 57 pp., 4 pls.

BULLETIN 366. Tests of coal and briquets as fuel for house-heating boilers, by D. T. Randall. 1908. 44 pp., 3 pls.

BULLETIN 367. The significance of drafts in steam-boiler practice, by W. T. Ray and Henry Kreisinger. 1909. 61 pp.

BULLETIN 368. Washing and coking tests of coal at Denver, Colo., by A. W. Belden, G. R. Delamater, and J. W. Groves. 1909. 54 pp., 2 pls. 10 cents.

BULLETIN 373. The smokeless combustion of coal in boiler plants, by D. T. Randall and H. W. Weeks. 1909. 188 pp. 20 cents.

BULLETIN 382. The effect of oxygen in coal, by David White. 1909. 74 pp., 3 pls.

BULLETIN 385. Briquetting tests at the United States fuel-testing plant, Norfolk, Va., 1907-8, by C. L. Wright. 1909. 41 pp., 9 pls.

BULLETIN 392. Commercial deductions from comparisons of gasoline and alcohol tests on internal-combustion engines, by R. M. Strong. 1909. 38 pp.

BULLETIN 402. The utilization of fuel in locomotive practice, by W. F. M. Goss. 1909. 28 pp.

BULLETIN 403. Comparative tests of run-of-mine and briquetted coals on the torpedo-boat *Biddle*, by W. T. Ray and Henry Kreisinger. 1909. 49 pp.

BULLETIN 412. Tests of run-of-mine and briquetted coal in a locomotive boiler, by Walter T. Ray and Henry Kreisinger. 1909. 32 pp.

BULLETIN 416. Recent development of the producer-gas power plant in the United States, by R. H. Fernald. 1909. 82 pp., 2 pls. 15 cents.

BULLETIN 428. The purchase of coal by the Government under specifications, by G. S. Pope. 1910. 80 pp.





